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VOL. XXXII. — No. 10. OCTOBER 1955.

Monthly Bulletin of the International Railway Congress Association

(English Edition)

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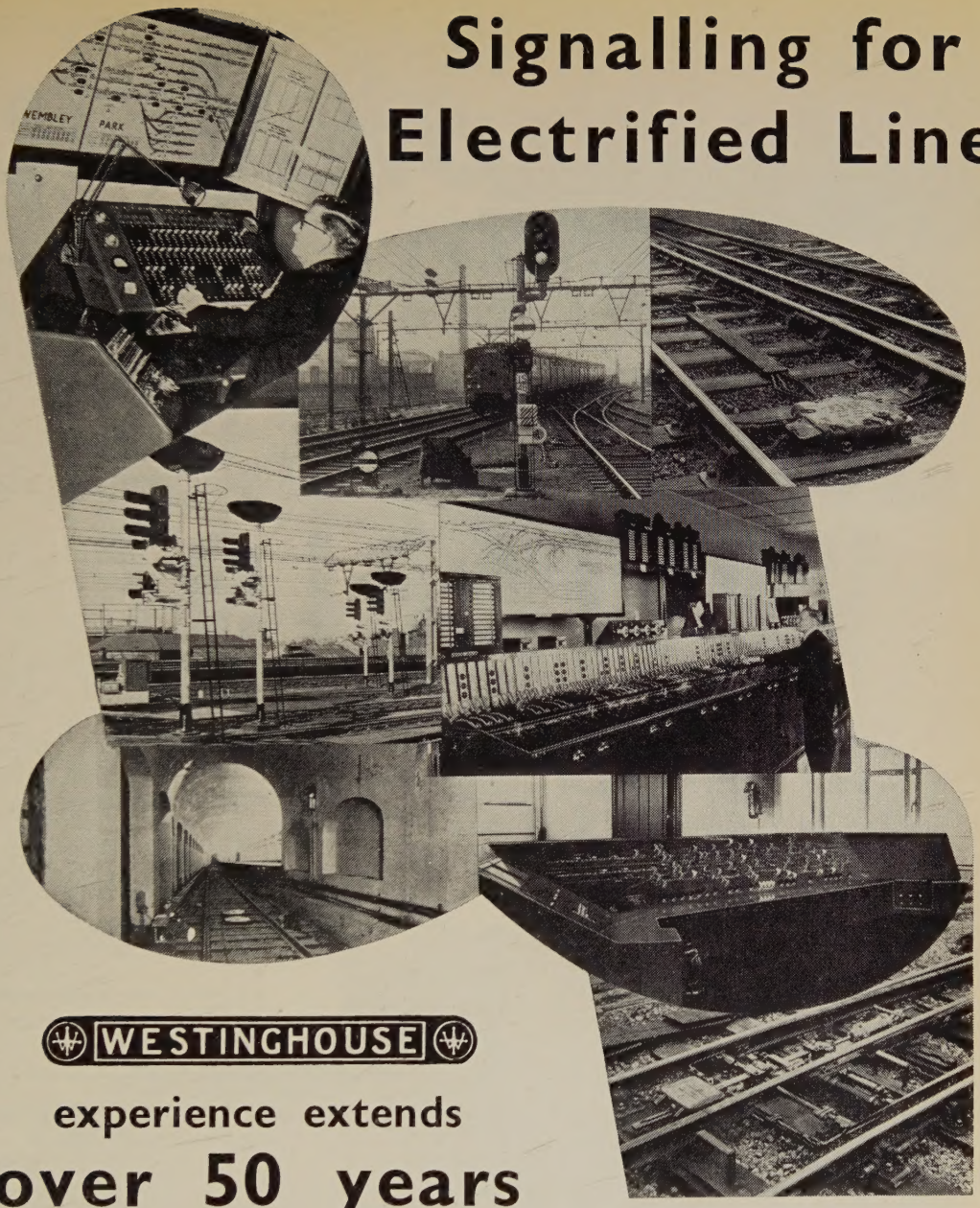

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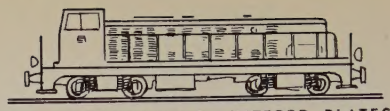

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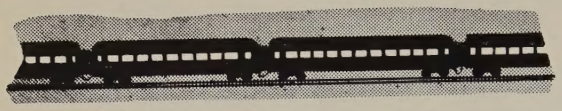

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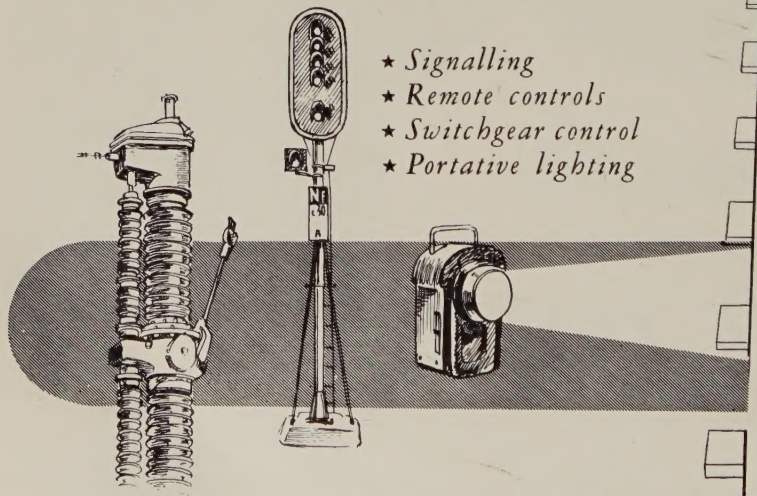

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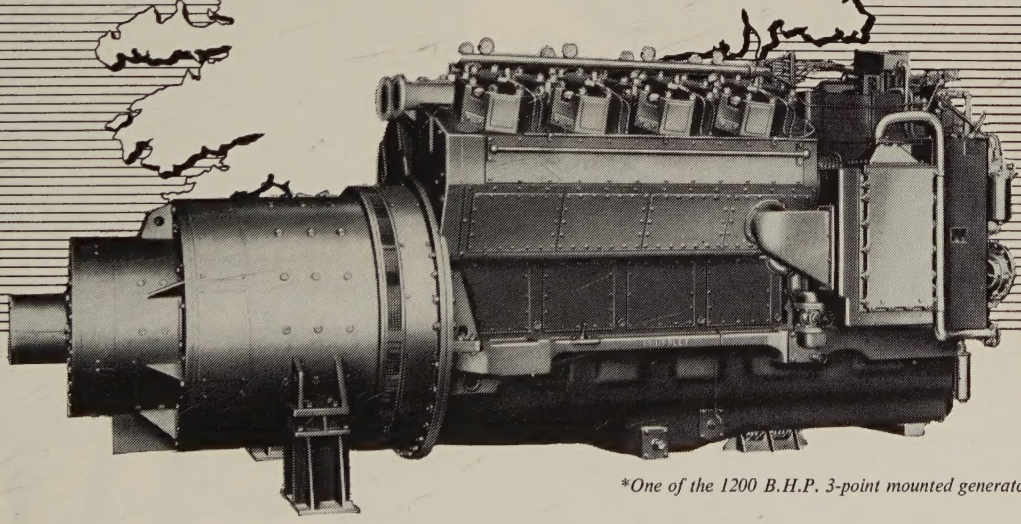

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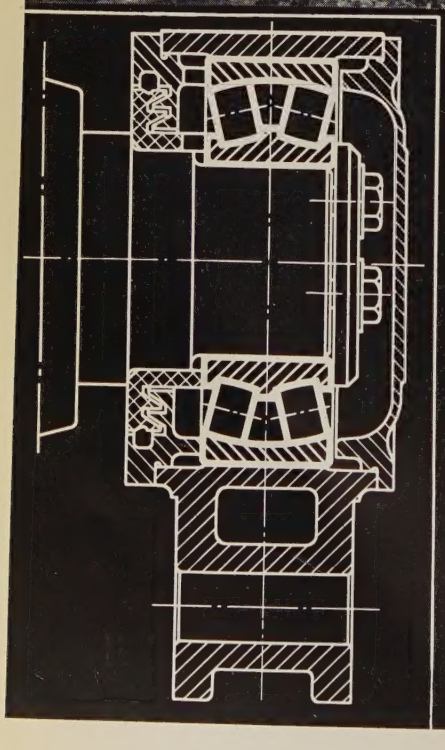

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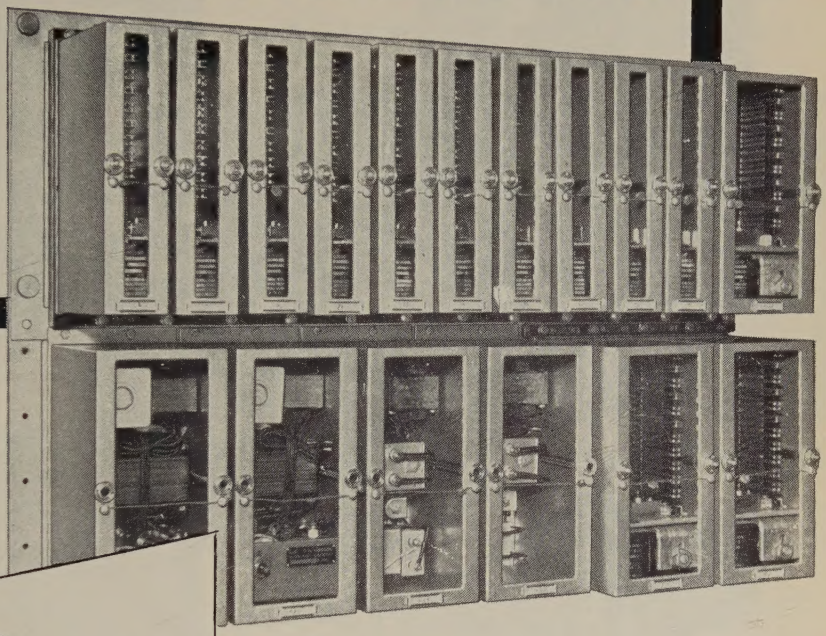
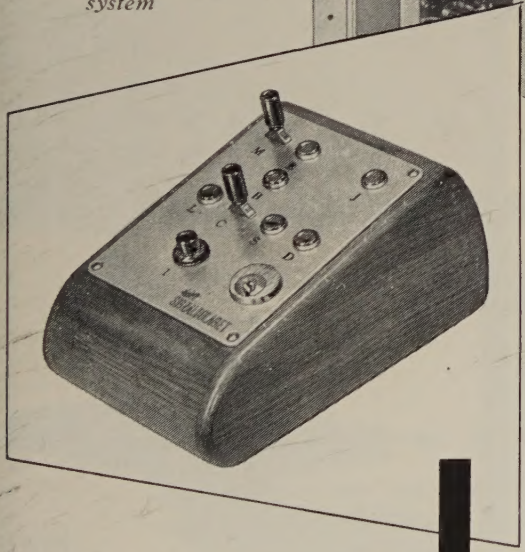


Manual block relay equipment

Control panel for manual block system



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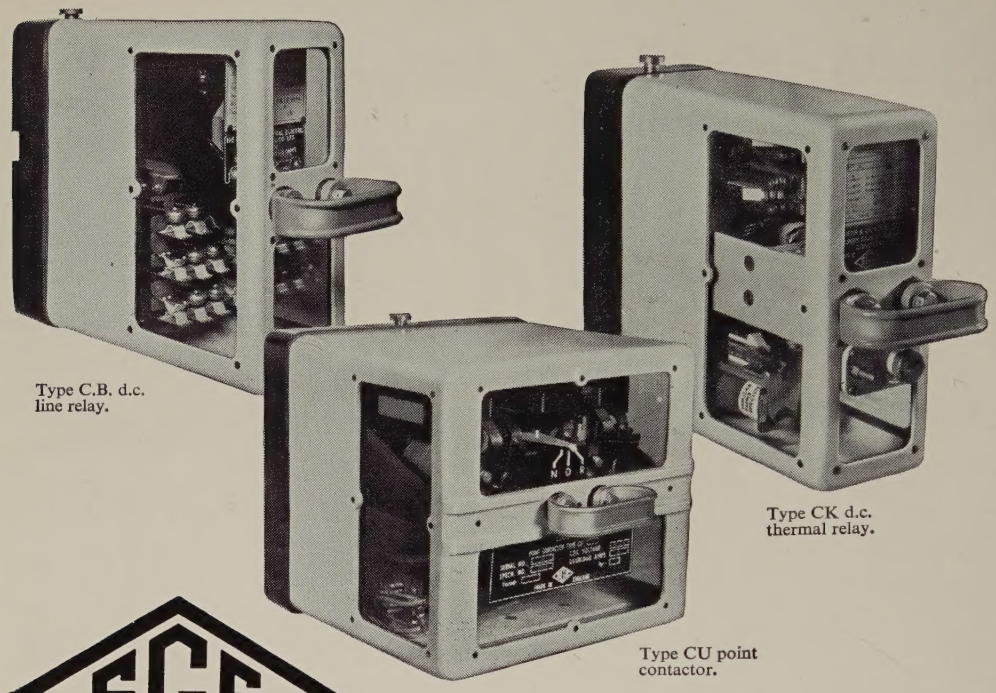

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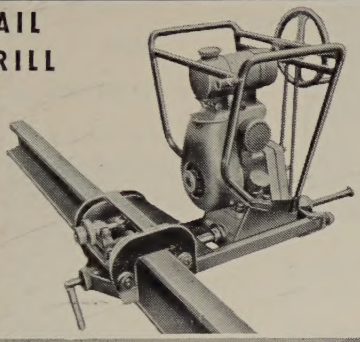

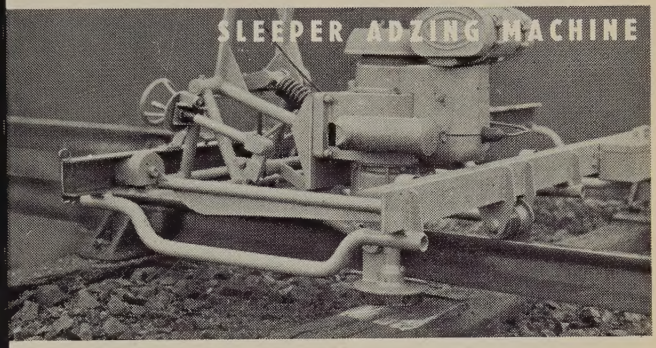

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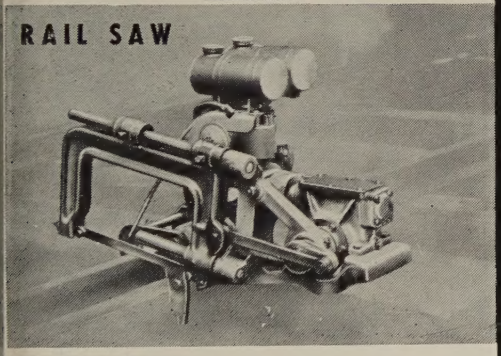

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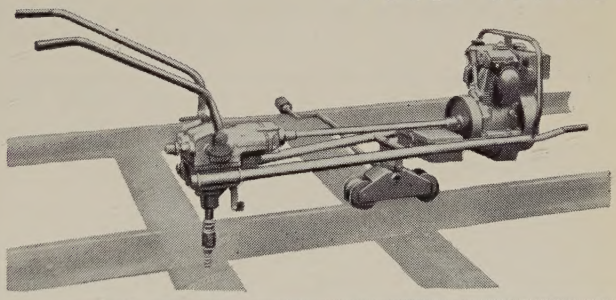

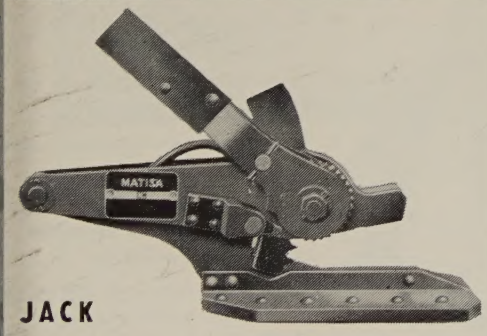

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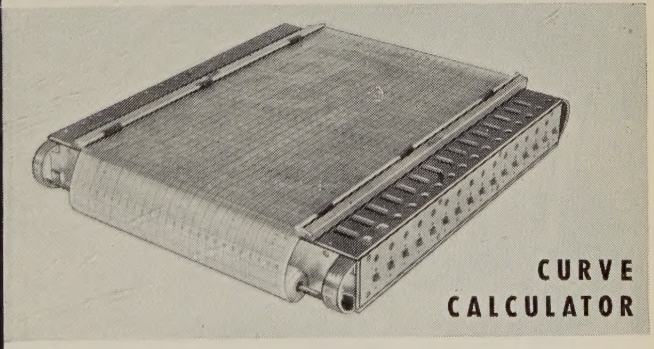

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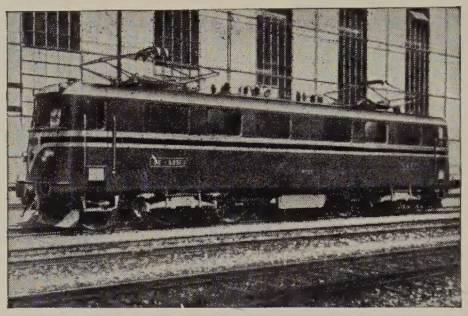

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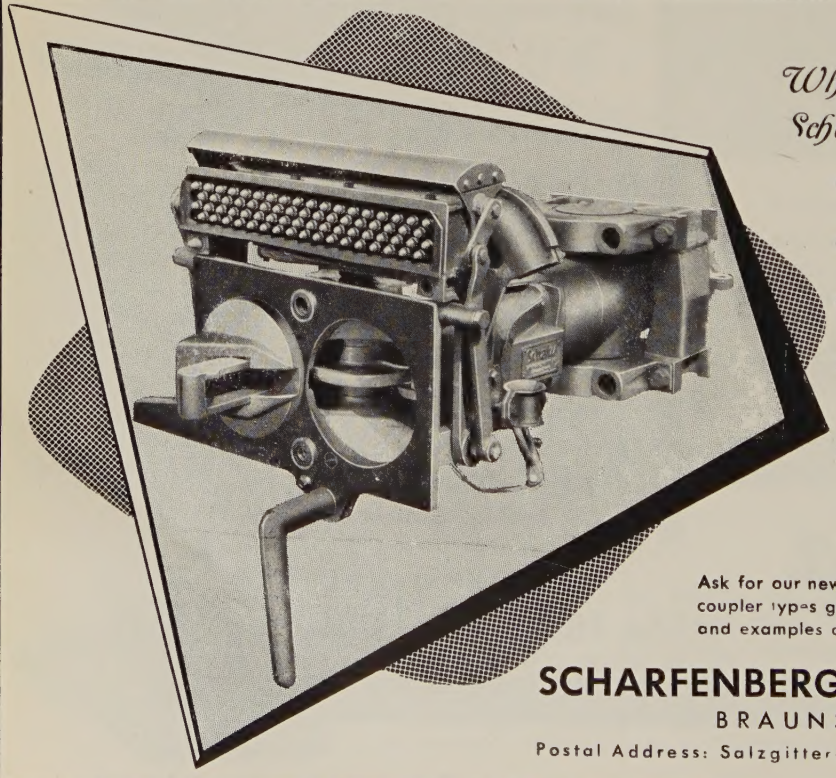

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(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

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Vol. XXXII. — No. 10. October 1955.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .337]

Individual axle drive.

Mechanical systems used on electric locomotives and motor coaches, with an indication of the results obtained in service on railways of all kinds,

(Continued and concluded)*

by Adolphe-M. HUG,
Consulting Engineer, Thalwil (Zurich), Switzerland.

CHAPTER VII

RACK RAILWAYS

This Chapter (✣) continues what has previously been described (407) and in line with the arrangements throughout the work, the earlier descriptions will not be repeated; the following text will, however, refer to them as necessary (408).

With regard to electric locomotives of new types, in Switzerland, 1953/54, we may mention, in order of their being put into service, $B_0'B_0'$ locomotive No.31, of the Bex-Villars-Bretaye electric railway, BVB (Alpes vaudoises, autumn, 1953) and two $B_0'B_0'$ locomotives, Nos. 1991 and 1992 (summer, 1954) for the Brünig line of the Swiss Federal Railways, SBB-CFF-FFS. These two types of machine, class HGe $^4/_4$ (Swiss designation) are metre gauge and operate either by adhesion or by rack.

1) *BVB locomotive No. 31* (409).

Up to the present time, throughout the world, on rack gradients of 170 $^0/_{00}$

(*) See *International Railway Congress Bulletin* for February 1953, p. 65; May 1953, p. 245; November 1954, p. 1069; July 1955, p. 469 and September 1955, p. 623.

(✣) At the end of Chapter VI, which is the longest (*Congress Bulletin*, July and September 1955) it was stated in error that Chapter VII would be the final one. Chapter VIII will follow, dealing with internal combustion engine traction and Vol. III of this work will contain a Supplement, in the same way as Vol II, 1950.

(407) See *Vol. I*, pp. 98 to 101 (fig. 198 to 202), and *Vol. II*, pp. 205 to 216 (fig. 262 to 275) (*Congress Bulletin*, January 1949).

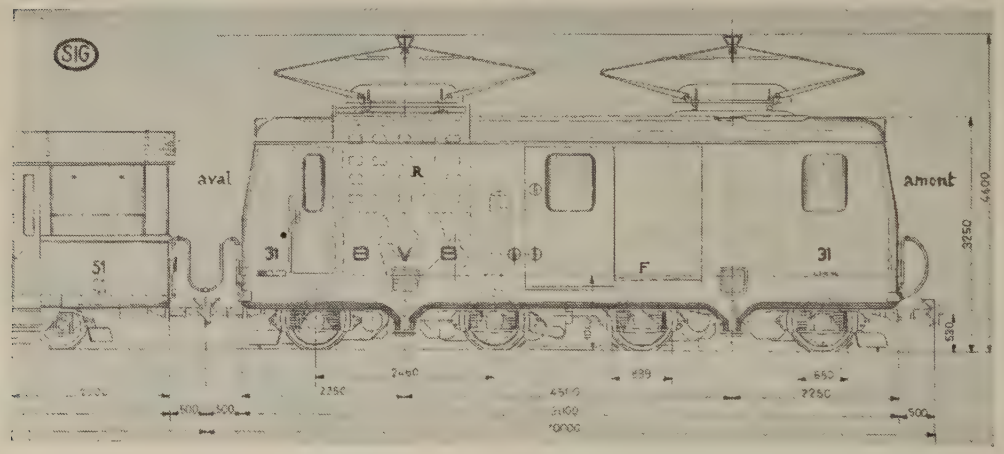
(408) See the publications dealing generally with rack railways and their recent developments, as well as the various standard types of transmission and their arrangement. In particular, the publications mentioned in notes (155) and (169) of *Vol. II*.

— *Revue Technique Suisse*, *STZ*, No. 51-52 of 23-12-48, « Recent developments in the construction of the mechanical parts of electric motor coaches for all-racks lines and for combined rack and adhesion lines, with particular reference to transmission and brakes », 8 pp., 12 figs., and diagrams, line maps., A. MEYER.

(409) See E.T.T., Nos. 1-3, 1954, pp. 20-24, 2 figures, A. WATTENHOFER (in French and German, continuation and conclusion of an article dealing with various new features on the BVB). See note (410).

— *Revue Suisse du Trafic et de l'Industrie*, Zurich (A. Grob SA.), August 1954, pp. 40-43 (French and German), 2 figures.

and above, sets have been propelled only on the rising gradient and held on the falling gradient. That is to say, the locomotive, or motor coach, would always be at the lower end of the set. When the new machines, however, were put into service the responsible authorities decided to allow the locomotives, for the first time, to haul a train from the front end, or to remain at the rear of the train, on or barely more than 6 t per axle, which is quite remarkable for an electric rack locomotive. The mechanical parts weigh 19 t and the complete electrical equipment 5.5 t. The total weight of the new train can reach 58 t. The machine can haul a load of 32 t (two light coaches of 7 t each with a total of 240 passagers and a ski-carrying wagon) on a gradient of 200 °/oo at a speed of 16 km/h (10 m.p.h.);



Plan SIG.

Fig. 578. — Elevation of electric rack and adhesion locomotive No. 31, $B_0'B_0'$, of the BVB Railway.
R = ventilated resistances;
F = compartment for heavy baggage or other freight (brake compartment).

the downward journey also, which simplifies operation.

Figure 578 shows an elevation of the BVB locomotive — which is in fact a motor brake van regarded as a locomotive — and figure 579 shows the complete set on an up-gradient. The dimensions of the machine are shown (figure 578) and other details are as follows :

the one-hour rating is 4 × 125 HP = 500 HP and the tare is only 24.5 t, downwards, speed on the rack is 14.5 km/h maximum. With adhesion the normal speed is 30 km/h (18 m.p.h.) (maximum speed = 35 km/h ([21 m.p.h.]). The various normal and automatic brakes are mentioned in the article referred to in note (409).

The BVB Railway (formerly the BGVC) has put into service since 1940, electric motor coaches, type CFeh $^2/_4$, Nos. 21 to 26 (figures 264 to 267), which have already been described (410). The older

(410) See *Vol. II*, Chapter VII, pp. 209-210, figures 264-267; see E.T.T., No. 1-3, 1933, pp. 7 and 8, figures 4, 5, 10, 12-13, « New rolling stock for the Bex-Villars-Bretaye Railway », A. WATTENHOFER.
The designation of BVB motor coaches was changed in the summer of 1954; series 21 instead of 91.

locomotives with two driving axles are still in service but because of their low speed and limited power, they are used only for goods trains and for snow clearance. The maximum gradient on the rack is 200 °/₀₀; the supply system is 700 V D.C. on the contact line.

Neuhausen (Chute du Rhin) which has already been mentioned several times earlier, for the mechanical parts, and by Oerlikon (MFO) for the electrical equipment.

The drive can be described as follows : The armatures of the traction motors

Block E.T.T. (Photo SIG).

Fig. 579. — View of machine No. 31, BVB, shown in figure 578, hauling the two new vehicles on a 20 % gradient on the line between Villars and Bretaye.

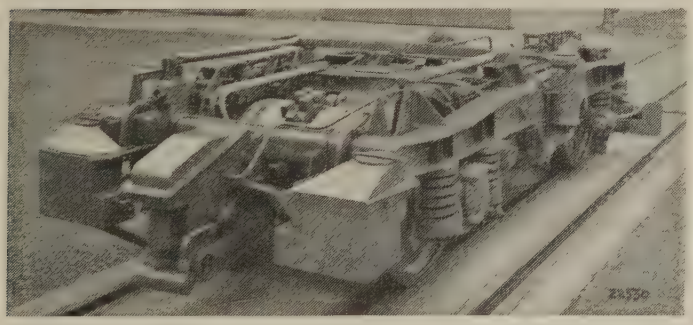


Fig. 580. — Bogie of the locomotive in figures 578 and 579 from the inside end. The two bogies are alike. This shows the double pinion, Abt system.

Photo : SIG-Neuhausen.

Figure 580 shows one of the two bogies with two motors, of this new modern machine, the behabiour of which is in all respects good and constitutes an incontestable success as well as an interesting innovation.

This locomotive was built by SIG, are connected to the transmission by a friction coupling which has a limited torque. This coupling, which is easily accessible from the exterior of the locomotive (see figures 578 and 580) is adjusted so that the maximum tractive effort is transmitted without slip by the coupling

to the geared driving wheels. If the moment to be transmitted increases abnormally for any reason, the friction coupling springs begin to slip and damage is thus safety avoided. The permissible speed on a falling gradient of 200 °/₀₀ is 14.5 km/h; if this speed is exceeded and reaches 19 km/h a circuit-closer, worked by centrifugal force, from the adhesion (flanged) wheels, actuates the compressed air brake (Charmilles) and simultaneously cuts out the electric brake.

The arrangement of the combined adhesion and rack traction mechanism is thus different from the normal type of drive, but the fundamentals are the same, the motor driving the axle on which are mounted the rack pinions, which run free (with the axle) whilst running by adhesion. Each motor thus drives the complete axle for adhesion and for rack working. Efforts have been made to ensure the greatest degree of stability for the locomotive and to arrange the bogies to avoid any tendency, even with the heaviest pressures on the cogs, to climb the rack. The transmission of the power of the motors to the pinions (in engagement with the rack) is therefore flexible and the balance of the cog pressures of the pair of pinion wheels of each bogie is as near perfect as possible. The pinions, of high quality, by the MAAG Gear Co., Zurich, are ground to provide noisefree running.

The total weight of the train (58 t maximum) on a 20 °/₀ gradient gives a downward pull of about 11.5 t. The adhesion wheels being permanently connected to the driving pinions by reduction gears, it is possible sufficiently to increase the brake force (brake shoes on the tyres) on heavy falling gradients to ensure the stopping of the train. To render this increased braking independent of the attention of the driver, a special device has been provided (with an illuminated red indicator light in each of the two driving positions) automatically increasing the pressure of the brake blocks when running on the rack. Band brakes, acting as a differential brake in the two directions of travel, are mounted on drums rigidly connected to the pinions and operated by a handle from each driving position. The normal braking when descending is electric, the traction motors acting on the braking resistances. Contrary to the arrangements with motor coaches which run down with the pantographs lowered, machine No. 31 has the pantograph always in contact with the line, to supply constantly power to the safety and ventilation equipment which is essential for cooling the resistances.

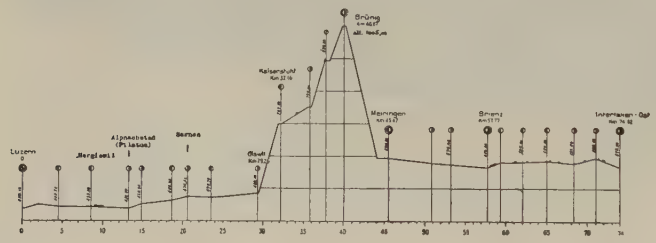


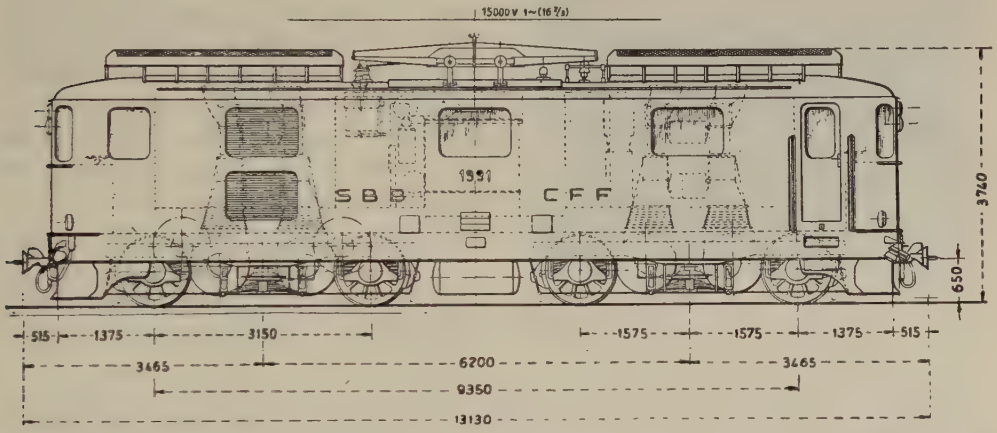
Fig. 581. — Profile of the Brünig line (metre gauge) of the Swiss Federal Railways SBB-CFF. Scales, length 1/1 000 000 height, 1/25 000. The heavy gradients in the centre are the rack sections.

Plan CFF.

2) *SBB-CFF locomotives Nos. 1991-1992.*

Since the 15 kV, single phase, 16 $^2/_3$ cycle electrification, 1940-42, of the Brünig line (Lucerne-Meiringen-Interlaken), the line has been operated by 16 motor brake vans, type Fhe $^4/_6$, Nos. 901-916, already described (411). Figure 581 shows the gradient profile of the line from Lucerne to Interlaken East; the maximum gradient provided for is only 120 $^0/_{00}$.

The tare is 54 tons, the axle load being limited to a maximum of 14 tons. These locomotives can haul 120 t on a 120 $^0/_{00}$ rising gradient, that is double the load of the motor brake vans (of the same tare), series 901 (figures 274 and 275); on the other hand, their speed on adhesion has had to be limited to 50 km/h (in place of 75) to retain economy of operation.



Plan CFF 17864.

Fig. 582. — Dimensioned elevation of locomotives Nos. 1991 and 1992, $B'_1B'_0$ type, class HGe$^4/_4$ of the CFF, for combined rack and adhesion work, 1954.

The new machines, class HGe $^4/_4$, 1991-92 (412) which are shown in figures Nos. 582 (dimensioned sketch) and 583, develop a one-hour power of 2 300 HP and are thus the most powerful so far built for a narrow-gauge rack line. The maximum speeds are 33 km/h on rack and 50 km/h on adhesion. The normal speeds on rack are 30 km/h ascending and 19 to 30 km/h descending, according to the gradient.

The bogies (figure 584) have an all-welded tubular frame carried on each side on two pairs of coils springs and through these on the axleboxes. The axles rotate in oil-lubricated conical roller bearings. The two bogies are linked by a transverse spring coupling, the purpose of which is to reduce stresses on the track in the many sharp curves and to reduce wear on wheel flanges.

(411) See *Vol. II*, p. 215, *h*), figures 274-275 and note (168).

(412) See *Bulletin des CFF*, Berne, No. 6, 1954, pp. 84-85. 4 figures, « Rack and adhesion electric locomotives HGe$^4/_4$, Nos. 1991 and 1992 of the CFF Brûnig line ».

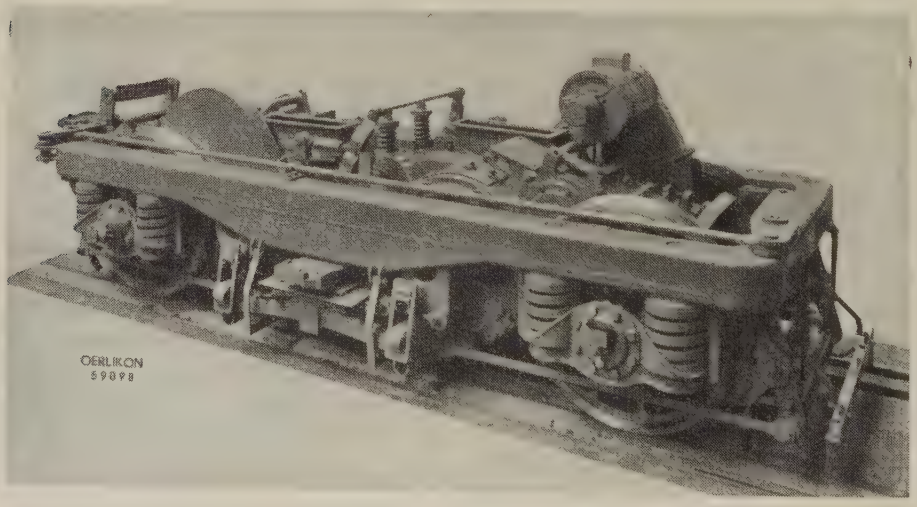
Each bogie is fitted with two traction motors, with nose suspension, of a one-hour power of 425 HP each. Each motor drives an intermediate shaft by a pair of gear wheels and by means of two other gears, the corresponding axle and the driving pinion which is free on the driving axle. This arrangement, which is shown in figures 582 and 584 means that the driving pinions rotate continuously, even when running on adhesion; it is not necessary to set them in operation and synchronise the movement before engaging with the rack, which greatly simplifies driving.

Photo CFF 2748-25.

Fig. 583. — Locomotive of figure 582, No. 1991, CFF, at Brünig station (adhesion).

These machines thus have only four driving axles serving both for adhesion and for rack, whilst the motor brake vans, series 901, have three 2-axle bogies of which the two outer ones (each with two traction motors) serve for adhesion, the central carrying bogie including the two motors for the rack pinions.

For the uniform distribution of the load of the braking resistances on the roof, the single current collector is placed in the centre, which is really not important



Construction SLM.

Fig. 584. — Two-motored bogie of the locomotive in figures 582 and 583, of the Brünig CFF line, with double gear reduction. The rack pinion can be seen on the right-hand axle.

because of the close spacing of the bogie pivots, only 6.2 m.

In addition to the speed restricting devices, these machines have *five* brakes, independent of each other, i.e. :

a) electric brake with resistances;

b) automatic air brake, acting on the locomotive and the train;

c) direct air brake acting on the locomotive wheels;

d) band brake acting on the driving pinions;

e) hand brake acting on the drums of the band brake fixed to the armature shafts.

Each of the three brakes in items *b*, *d*, and *e* would be sufficient alone to stop a train of a locomotive and the permitted number of vehicles on the steepest falling gradient.

The general and detailed design of the new locomotives is the result of joint work by the Traction and Workshops Division of the CFF, the SLM Company of Winterthur, the Oerlikon (MFO) Works and the Brown-Boveri Company (BBC).

It may also be noted that these two types of locomotives under headings **1)** and **2)**, the No. 31 BVB (and the new set in figure 579) and the series 1991 CFF (as well as all the rolling stock of the Brünig line) are fitted with automatic drawgear +GF+ type by G. Fischer of Schaffhouse ([413]).

We now pass *to motor coaches*, mostly light types, which could almost be called electric railcars for rack railways and deal firstly with a vehicle which is also of a completely new type, in the sense that it refers to a former funicular, successfully converted in 1950 to an electrically-operated rack railway (without cable).

3) This is a small railway, only 324 m long, from the centre of St. Gall (Switzerland) to the upper district of Mühleck, almost entirely by tunnel, with a maximum gradient of 228 °/₀₀ ([414]). A single motor coach of St. G-M, No. 1, class He 1/2, fulfils the operation at a speed of 12 km/h; one-hour rating of the single traction motor 130 HP, gauge 1 200 mm, 3-phase industrial current, 500 V, 50 cycle, diameter of the carrying wheels 525 mm, ∅ original circumference of the driving pinion 573 mm.

The tare of this motor coach is only 9 t (1.9 t of which is the electrical equipment) and the total load with 60 passengers (30 standing) is 13.2 t.

Figures 585 and 586 respectively show the transmission mechanism and the coach in service on the line (operated by the Verkehrsbetriebe der Stadt St. Gallen, VBSG).

The asynchronous, 3-phase motor, placed longitudinally, drives the traction pinion by means of a cardan, conical gear, reducer and clutch. Builders are SLM, Winterthur, for the mechanical parts and

([413]) See *E.T.T.*, Nos. 10-12, 1952, « Automatic drawgear for secondary railways and tramways », 4 p., 7 figs., part H of article, « Some special features affecting railway operating economy », Ad.M. Hug.

([414]) See *Der Öffentliche Verkehr*, Berne (French and German)., No. 12, 1950, p. 16, 4 figs., « A cable railway becomes a rack railway ».

— *Brown-Bovery Revue*, Baden, Switzerland, Aug.-Sept., 1952, pp. 345-347, 3 figs., « Conversion of a funicular to a rack railway », J. Schneider.

Brown-Boveri for the electrical equipment.

The conversion of the former funicular « Drahtseilbahn St. Gallen-Mühleck » (operated by water ballast, with two coaches passing at the centre of the line) to the St. G-M electric rack railway has allowed a considerable increase in its carrying capacity and at the same time greatly reduced the operating costs. The passenger/hour capacity (in each direction) has increased by 20 % with the same ten-minute timetable, but it could be increased by continuous service from 400 to 700 passengers if the number of journeys per hour were increased from 6 to 10. The speed of travel has been increased from 1.3 to 3.3 m/sec. A single vehicle now serves instead of the two formerly used and cable maintenance has disappeared; a staff of 3-4 employees is needed in place of the former minimum of six. The annual operating costs have been reduced by 30 000 Swiss francs, or about 1/3.

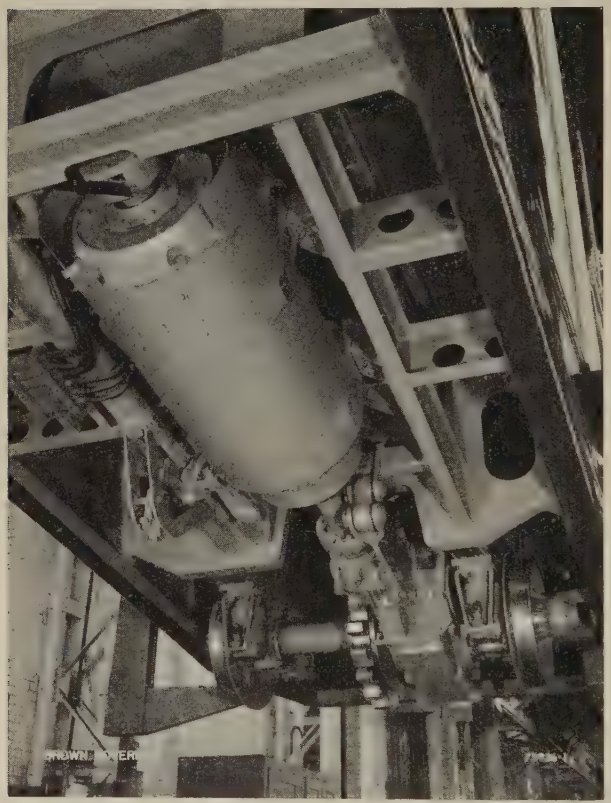


Fig. 585. — Underneath view of the three-phase motor and the drive of the motor coach in figure 586. This shows one of the two pairs of carrying wheels on the axle with the rack pinion, Riggenbach system.

Block BBC.

We have dealt at some length with this quite small railway because railways in various countries might benefit from a

Photo SLM 8248.

Fig. 586. — View of the St. G-M motor coach and the entrance to the tunnel. The two three-phase contact lines can be seen.

similar conversion, which is a noteworthy undertaking (see key to figure 585).

With regard to new electric rack *motor coaches*, either new types or continuations of existing types, we may note the following (still dealing with Switzerland) :

4) Mont Pilate Railway (Pilatusbahn) near Lucerne (figures 262 and 263); we are including two supplementary figures, Nos. 587 and 588, illustrating more clearly the steepness of the line and the driving arrangements of these two-axled motor coaches. These work on a *double-sided* rack (Locher) with gradients up to 480 °/₀₀. The track gauge is 800 mm. Because of the lateral engagement of the cogs, points and crossings can be negotiated only by means of a traverser table. Total stock of motor coaches at the end of 1954 was eight passenger cars, class Bhe 1/2, Nos. 21 to 28, one freight car, Ohe 1/2, No. 31; as spares there are (from pre-electrification times) two steam sets Nos. 9 and 10, class Xh 1/2. The builders are SLM for the mechanical parts and Oerlikon for the electrical equipment.

5) Gornergrat Railway (Gornergratbahn), GGB, also wholly rack-worked (see figure 268). There are now six cars, class Che 2/4, Nos. 101 to 106 ([415]) in

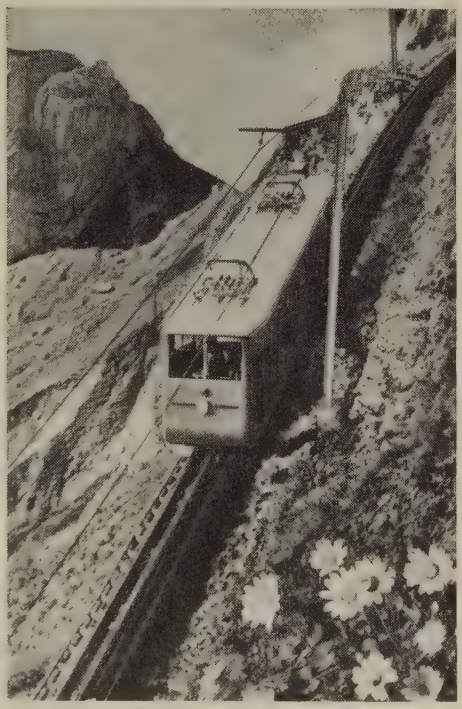
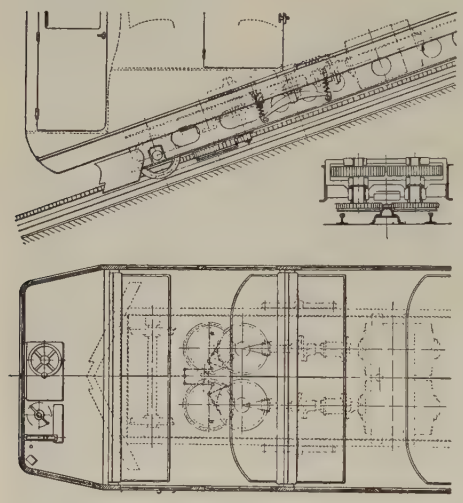


Photo Oerlikon P 49458.

Fig. 587. — Electric rack motor coach No. 21 of the Pilate Railway, descending. Electric resistance braking is used and the pantographs are lowered — they are used only on the up journey (cf. fig. 262).

([415]) See *E.T.T.*, Nos. 1-3 and 4-6, 1954, « New motor coaches of the Gornergrat Railway », (French and German), 10 p., 12 figs., K. Wullschleger.
— See also *Brown-Boveri Revue*, Baden, Switzerland, Dec. 1947, pp. 239-242, Ed. Hugentobler.

regard to which we are including figures 589, 590 and 591, bogies with one driving and one carrying axle, a dimensioned sketch of a car and a transmission diagram. Finally, figure 592 shows a pawl and ratchet brake used by the Gornergrat (and others).



Plan SLM.

Fig. 588. — Elevation, section and plan of the lower part of the two-axled cars of figure 587 of the Mont Pilate Railway (cf. fig. 263). This shows the band brake, on the conical gear of the transmission.

6) We have already mentioned (416) the BCF $^4/_4$ class motor coaches, series 101, of the Wengernalp Railway, WAB. With regard to figure 270, we are now including figure 593, showing motor coach No. 101 on one of the upper sections of the line, and figure 594, a diagram of the transmission. There are now five motor coaches in service, Nos. 101 to 105. We may recall that the WAB has a track gauge of 800 mm wholly racked, with 1 500 V D.C. Builders, SLM for mechanical parts and Brown-Boveri for the electrical equipment.

7) We now pass to the Bernese Oberland Railways (Berner-Oberland-Bahnen) BOB, which have not been mentioned previously. This is a combined rack and adhesion railway, 1 m gauge, 1 500 V D.C. from Interlaken East (see figure 581) to Grindelwald and Lauterbrunnen, and connects these two points to the WAB, previously mentioned.

The BOB Railway, electrified at the beginning of 1914, possessed in 1949, 9 C-type electric locomotives, with three rod-connected axles. It put into service, in 1949, three new motor coaches, class BCF $^4/_4$, Nos. 301 to 303 (417). Their appearance is very similar to that of figures 269 (A-L) and 270 (WAB), but they are a little larger; length over buffers 17 m, bogie spacing 10.8 m between centres, bogie wheelbase 2.95 m.

Figure 595 shows a bogie of these motor coaches and figure 596 a diagram of the transmission. The diameter of the driving wheels is 778 mm and of the driving pinions 637 mm. The maximum gradients are 25 °/₀₀ on adhesion and 90 °/₀₀ and 120 °/₀₀ on rack, for the Lauterbrunnen and Grindelwald lines respectively. The rack is of the Riggenbach system. The tare of the motor coach is 39.5 t, loaded 45 t. One-hour power (at the motor shaft) is 860 HP corresponding to 22 km/h. Builders are the same as in Item **6)**.

(416) See *Vol. II.*, pp. 211-214, figs. 270-271 (*Congress Bulletin*, January 1949).

(417) See *Brown-Boveri Revue*, Baden, Switzerland, Nos. 10-11, 1949, « Rack and adhesion motor coaches of the Bernese Oberland Railway », 7 p., 6 figs., Ed. HUGENTOBLER.

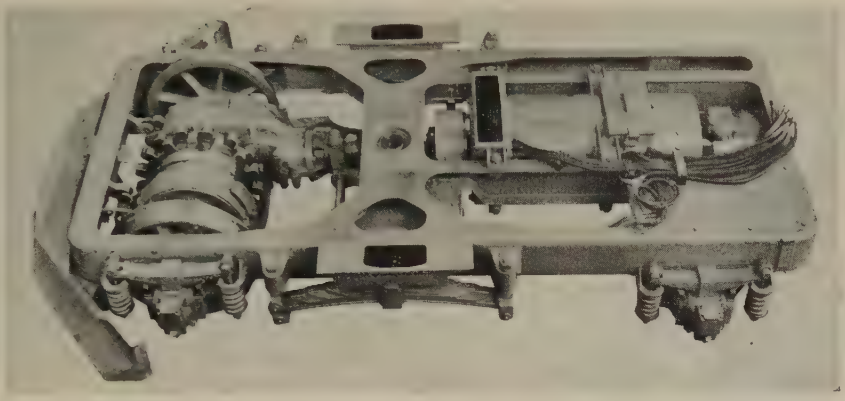


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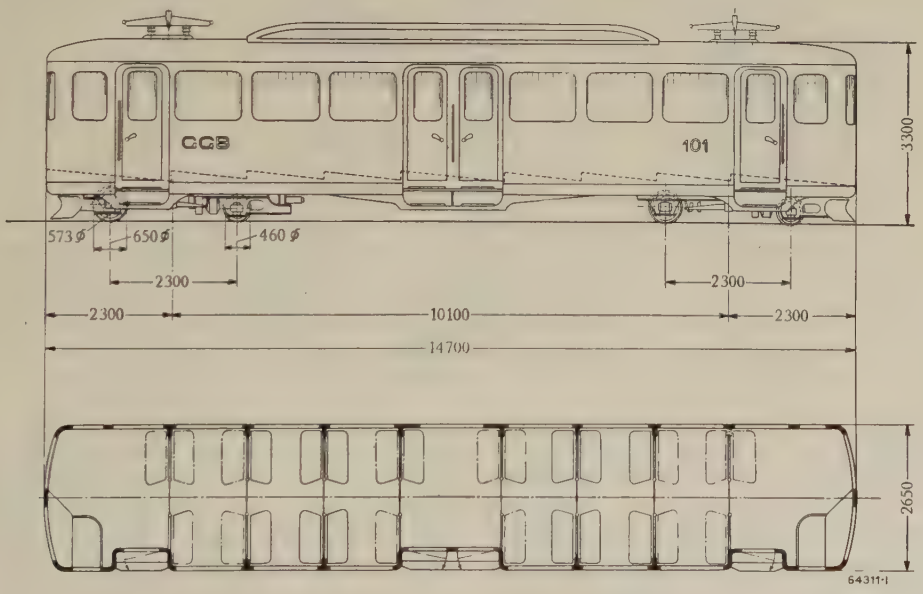
Fig. 589. — Bogie of motor coaches Nos. 101 to 106 of the Gornergrat Railway (fig. 268 and 590). Right (top end) above the carrying axle, the traction motor, arranged longitudinally, with the braking exciter. Left (bottom end), the driving axle, transmission, double rack (Abt system) pinion and the band and drum brake. Diameters of wheels : driving axle 650 mm; carrying axle 460 mm; pinions 573 mm; (cf. fig. 590).

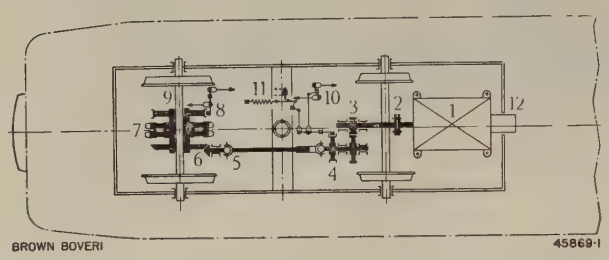


Block Brown Boveri.

Fig. 590. — Dimensioned elevation and plan of the six motor coaches of figures 268 and 589 of the Gornergrat Railway, GGB.

8) The two lines, St. Gall-Gais-Appenzell and Altstätten-Gais, a combined rack and adhesion service, amalgamated in 1951/52 under the name of the SGA (total mileage about 30 km) although the rack systems are different (Riggenbach and Strub) as are the line voltages (1 500 and 1 000 V D.C.). It has been possible to build and put into service three new motor coaches which can operate on the two types of rack and under 1 500 V, class BCFhe$^{4}/_{4}$, Nos. 6 to 8 (418). These motor coaches too are somewhat similar to those in figures 269 and 270 and we are including, in figure 597, only a diagram of the transmission.

The maximum gradients are, for the St. Gall-Appenzell section 92 °/oo on rack and 66 °/oo on adhesion; for the Altstätten-Gais section 160 and 52 °/oo respectively. The one-hour power is 640 HP at 22 km/h. The maximum speeds are 55 km/h on adhesion, 23 km/h on a falling gradient of 92 °/oo and



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1 = asynchronous, three-phase motor;
2 = flexible coupling;
3 = cylindrical gear;
4 = transmission brake, also automatically operated when a specified speed is exceeded;
5 = cardan shaft;
6 = conical gear;
7 = sprung, twin-rim, pinion;
8 = pawl and ratchet brake, also used as hand brake, when descending only;
9 = carrying axle;
10 = manual control of transmission brake;
11 = electro-magnetic device for releasing the spring of brake 4;
12 = exciter for rheostatic braking.

Fig. 591. — Diagram of the motor and transmission arrangement of the bogies in figures 589 and 590 (by SLM).

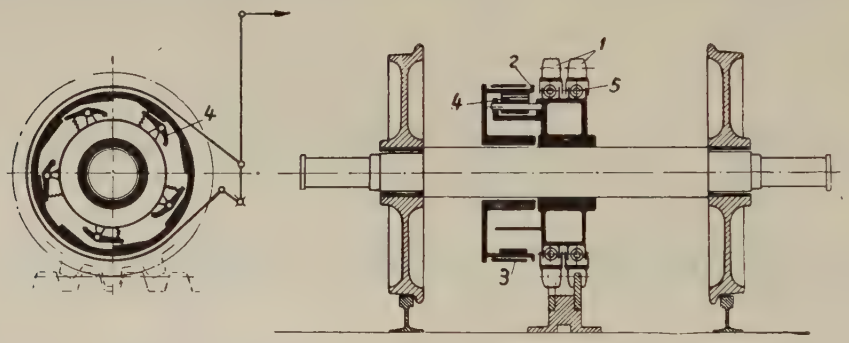

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Fig. 592. — Pawl and ratchet brake of the motor coaches in figures. 589 to 591, GGB.

1 = double pinion (Abt.);
2 = drum brake;
3 = band for drum brake;
4 = pawl;
5 = tangential springs under geared rim of pinion.

(418) See *Brown-Boveri Revue*, No. 8-9, 1952, pp. 347-348, with 2 figs., « The new motor coaches of the St. Gall-Gais-Appenzell-Altstätten Railway », J. SCHNEIDER.

Photo BBC 68670.

Fig. 593. — Motor coach No. 101 of the Wengernalp Railway, with trailer, in service during winter, on the upper section from Grindelwald to Kleine Scheidegg. In the rear is the Jungfrau chain (left, the Eiger, right the Monch and the Jungfraujoch).

16 km/h on a falling gradient of 160 °/oo. The maximum weight of the trains is 94 t. Same builders as for items 6) and 7).

9) The Arth-Rigi Railway (Arth-Rigi-Bahn) ARB, which serves the well-known Rigi mountain on the North side, starts from Arth-Goldau (a station on the St. Gothard line) and joins up near the summit of the mountain with the Vitznau line (419) (at the Lac des Quatre Cantons) serving the South side. The ARB is a normal gauge line operating wholly on the rack system (Riggenbach). Between 1949 and 1953 there were built for it, three bogie motor coaches, class CFhe $^{2}/_{4}$, Nos. 11 to 13, the general arrangement of which is again similar to those in figures 269 and 270 (420). Figure 598 shows coach No. 11 in service; figure 599 the bogie (each of the two bogies being fitted with a single motor arranged longitudinally) and figure 600 the arrangement of the wheels and drive.

The builders are SLM Winterthur for

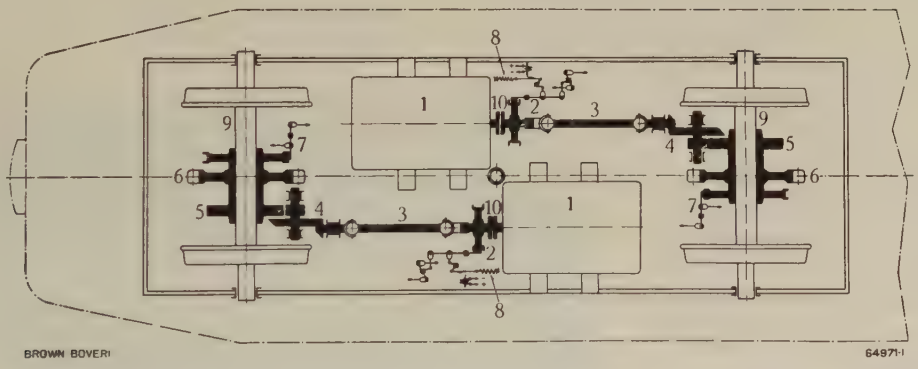

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Fig. 594. — Diagram of motors and transmission of a bogie of the coaches in figures 270 and 593 (by SLM).

1 = traction motor;
2 = transmission brake, operated manually or automatically if the speed exceeds a certain specified limit;
3 = cardan shaft;
4 = conical gear;
5 = cylindrical gear;
6 = sprung driving wheel;
7 = pawl brake on driving wheel, used as hand brake on downward journey only;
8 = electro-magnetic device for releasing spring of brake 2;
9 = carrying axle;
10 = friction coupling.

(419) The Rigibahn-Vitznau Railway, which has been electrified for a number of years, now has in service four motor coaches similar to those of the other lines mentioned.

(420) See *Secheron Bulletin*, Geneva, No. 21F, 1949, « High-capacity cars of the Arth-Rigi rack railway », 6 p., 7 figs., H. Werz.

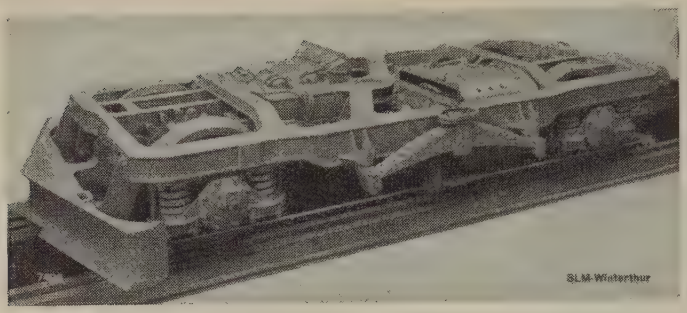
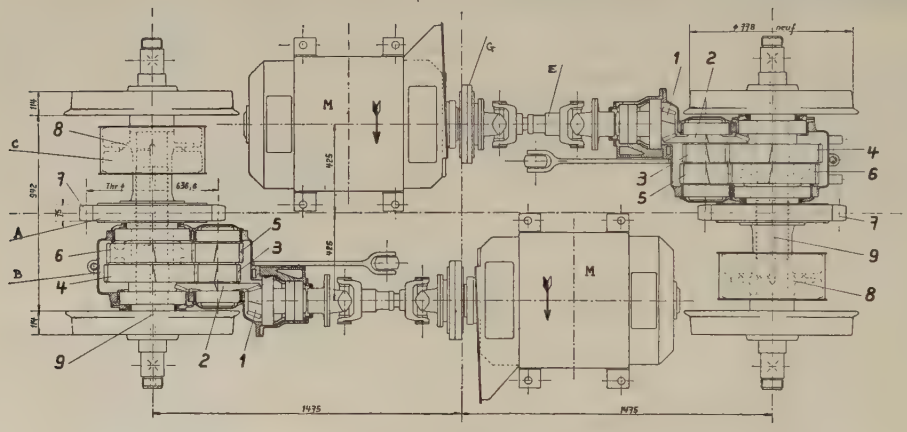


Fig. 595. — Bogie of the series 301 motor coaches of the BOB Railways in Switzerland. The rack pinion, on the two axles, is single (with one rim, Abt system), because of the relatively easy gradients (cf. fig. 596).



Plan SLM 12-12538.

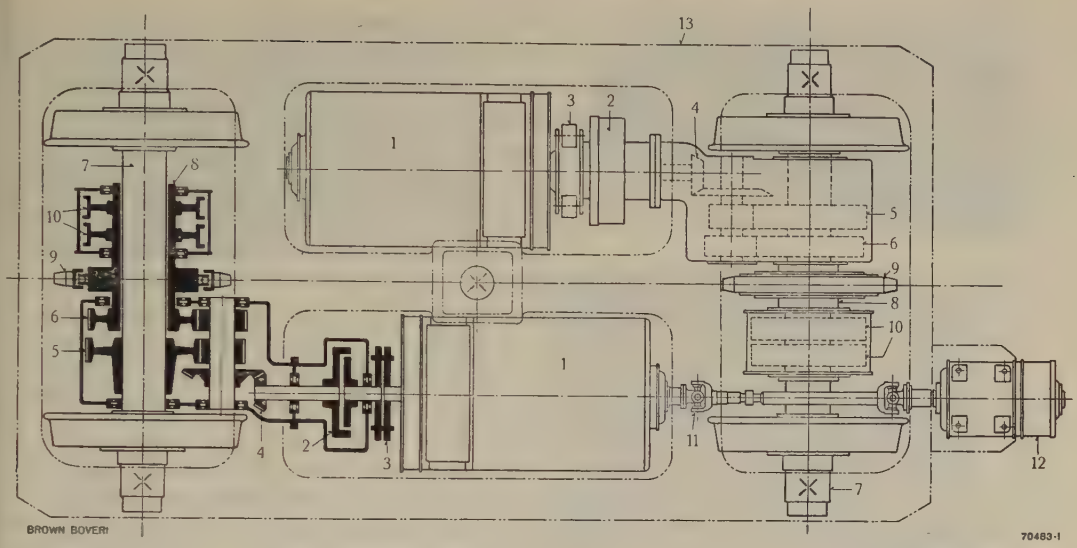
Fig. 596. — Diagram of motors and drive of the bogies in figure 595 (BOB).

A = pinion;
B = drive to the axle;
C = brake drum;
E = cardan shaft;
G = spring coupling;
M = electric traction motor;
1 and 2 = conical gears;
3-4 and 5-6 = oblique gears of the transmission;
7 = pinion;
8 = hub of brake drum;
9 = lubrication channel in the driving axles.

the mechanical parts and Secheron (SAAS) for the electrical equipment.

10) The Rorschach Railway, Rorschach-Heiden-Bergbahn, RHB (Lake Constance), Heiden, electrified about 1930 (single-phase, 15 kV, 16 $^2/_3$ cycles, because of the joint CFF and RHB line from the port to the station at Rorschach) had only two motor brake vans for postal services, class FZhe$^2/_4$, Nos. 21-22, and in 1953 ordered from Brown-Boveri (mechanical parts from SLM-Winterthur) a BCFhe $^2/_4$ motor coach No. 23, similar in appearance to those for other lines (421). Figure 601 shows a driving axle

(421) See *Brown-Boveri Revue*, Baden, Switzerland, Sept. 1953, « New rack and adhesion motor coach of the Rorschach-Heiden mountain railway », 4 p., 4 figs., E. ISLER.



Block BBC 70483-1.

Fig. 597. — Diagrammatic arrangement of the bogies of the motor coaches, BCFhe$^{4}/_{4}$, of the SGA Railway in Switzerland, showing the motors and transmission mechanism for adhesion and for rack working. The mechanical part was designed and manufactured by SLM-Winterthur.

1 = 160 HP traction motor;
2 = friction coupling;
3 = flexible coupling;
4 = conical gear;
5 = reduction gear for wheel drive;
6 = reduction gear for pinion drive;
7 = driving axle;
8 = sleeve carrying the gear wheel;
9 = pinion;
10 = brake drum, solid with the gear wheel;
11 = cardan shaft for driving 12;
12 = lighting generator;
13 = bogie frame.

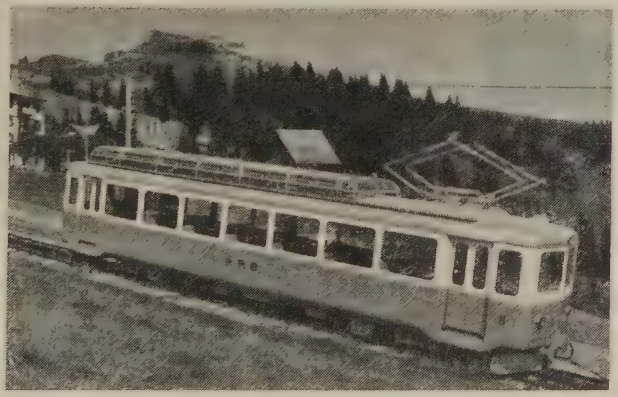


Fig. 598. — Rack motor coach No. 11 of the ARB Railway. In the background is the summit of the Rigi and the hotels. Below the summit can be seen, one above the other, the two lines, Rigibahn-Vitznau and Arth-Rigi-Bahn, ARB.

Photo SLM 7635.

for one of their bogies. The rack is of the Riggenbach system.

11) To conclude the Swiss vehicles, we will deal with the new motor coaches, 1953/54, for the combined rack and adhesion railway, Aigle-Ollon-Monthey-

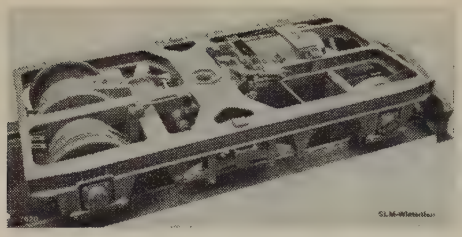
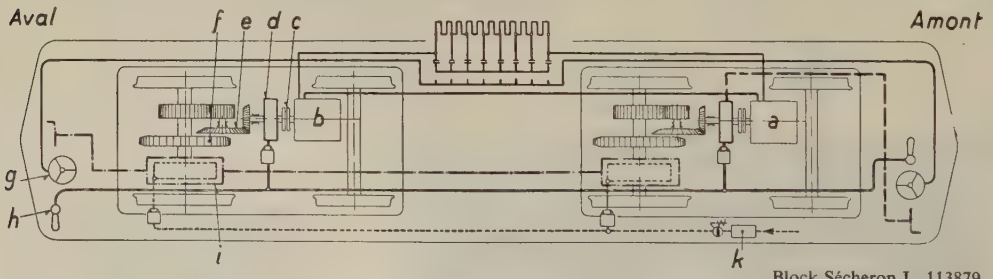


Fig. 599. — Single-motor bogie of motor coaches Nos. 11-13 of figure 598; left, the driving axle with cardan shaft and transmission; right, the carrying axle.

Champery (Morgins) AOMC, linking Aigle on the Simplon line (Rhone valley) with Champery (in the Illiez Valley, Valais, near the Haute Savoie frontier). This line is metre gauge (Strub rack) with electric traction (750 V D.C.).

This concerns *four* motor coaches, class CFeh °/₀, Nos. 11 to 14, with bogies, put into service on the 23rd May 1954; they constitute an innovation in the sense that this is the first time that use has been made on rack railways of a flexible transmission with cardan shaft and hollow armature shaft (Brown-Boveri discs) (422).

Figure 602 shows one of the motor coaches in service, figure 603 the driving bogie and figure 604 an elevation and front view with dimensions. Each bogie is provided with two electric motors of 125 HP each, the one-hour power of the coach being 500 HP. The motors drive by a torsion bar in the armature and by way of a friction coupling; the actual transmission, of the SCHINDLER type, controlling the tractive effort on rack and adhesion. It may be pointed out that the effort is transmitted by two pairs of gears one pair acting on the two adhesion driving axles and one pair on the two rack driving axles. The geared rims are mount-



Block Sécheron L. 113879.

Fig. 600. — Arrangement of a full set of wheels and drive of the motor coaches Nos. 11, 12 and 13 (figs. 598 and 599) of the ARB Railway.

a and b = traction motor;
c = friction coupling;
d = band and drum brake;
e = gear train;
f = pinion;
g = controller;
h = driver's valve (Charmilles type);
i = pawl and ratchet brake;
k = air reservoir for emergency brake.

electric resistance brake.
hand brake on the transmission.
manually controlled pawl and ratchet brake.
pneumatic brake, direct action, on the transmission.
pneumatic emergency brake, acting on the pawl and ratchet brake.

(422) This transmission, apart from the differences due to the combined drive (rack and adhesion), is similar to that in figure 239. It could consequently have been noted under heading 17) on the page following figures 576-577.

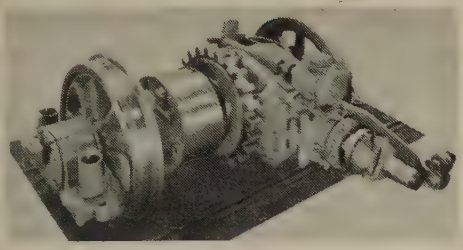


Photo SLM 8995.

Fig. 601. — Driving axle, with cardan, transmission, rack pinion and drum brake, for motor coach No. 23 of the mountain railway Rorschach-Heiden.

ed on springs to compensate the gearing when entering the rack system. These motor coaches are designed for a maximum speed of 50 km/h on adhesion and on rack working of 25 km/h ascending and 18 km/h descending; they are also fitted with five brakes, viz : automatic air brake, hand brake, electric brake on resistances, electro-magnetic rail brake and safety brake, the latter acting directly on the motor shaft if the air pressure falls below a certain minimum ([423]).

The maximum gradient is 135 °/₀₀ on rack and 65 °/₀₀ on adhesion. The tare of the motor coach is 30 t, of which about 7.5 t is electrical equipment. The number of seats, including tip-up seats, is 51.

The builders are, for the mechanical parts and transmission, Schindler Waggon Works, Pratteln, near Basle, SWP, and for the electrical equipment, Brown-Boveri, BBC.

There are also in Switzerland other rack railways with stock which is relatively modern or is in course of modernisation — in addition to those mentioned in this chapter and in Chapter VII of *Volume II* — amongst which may be mentioned the combined rack and adhesion railway, operating with three-phase traction current [like the GCB, item 5)], from Stansstad

Photo AOMC.

Fig. 602. — CFeh$^{4}/_{4}$ motor coach No. 13 of the AOMC Railway on a rack section above Monthey (Valais). In the background, the Rhone.

N. B. — The AOMC Railway has revived an old custom in giving a name to each of its four new motor coaches; for Nos. 11 to 14, these are : « La Haute Cime », « La Cime de l'Est », « Les Dents Blanches » and « La Dent Jaune » (four summits in the mountain range known as the « Dents du Midi — Dents Blanches », which run alongside the line).

([423]) See *Revue Suisse du Trafic et de l'Industrie*, Zurich (A. Grob, SA.), August 1954, « New motor coaches of the Aigle-Ollon-Monthey-Champery Railway », 2 p., 2 figs.

to Engelberg, St-E. (Unterwald canton); the Jungfrau (Bernese Alps) JB, all-rack, metre gauge, also three-phase; Brunnen to Morschach (Lac des Quatre Cantons), etc.

To conclude this Chapter we will now deal briefly with three modernisations of rack railways in other countries, i.e. **12**) in France and **13**) and **14**) in Germany. Other rack railways have prepared schemes for modernisation, particularly in France, Italy, Germany and Spain, apart from other countries overseas.

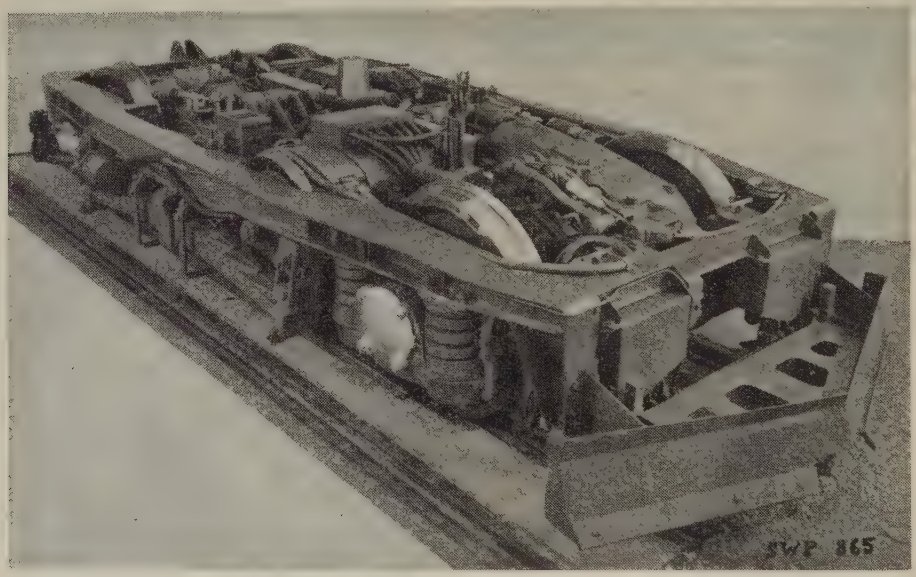
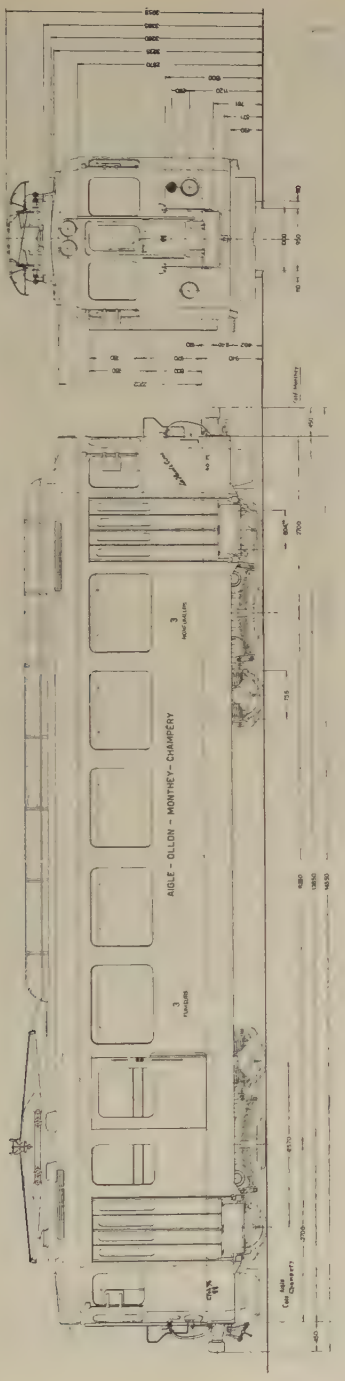


Photo Schindler SWP-865.

Fig. 603. — Driving bogie of the AOMC motor coaches in figure 602, for combined rack and adhesion service, with hollow axle and cardan and disc drive (Brown-Boveri, see fig. 239 and 560). Maximum speed on rack = 25 km/h.

12) The rack and adhesion railway from Chamonix to Montenvers (Mer de Glace, Haute Savoie), C-M, one metre gauge, which was electrified in 1953/54, single phase, 10.5 kV, 50 cycles. Figure 605 shows an elevation and front view of the top end of the three motor coaches Nos. 41 42 and 43. Under the Swiss designation these are class Che $^4/_4$, with four driving axles of which the one at the lower end is for combined traction and the three others are rack only. This operates on the Abt system, with maximum gradients of 250 $^o/_{oo}$ on rack. The one-hour power is 640 HP (4 × 160) at a speed of 15 km/h, maximum speed 20 km/h. The tare of these motor coaches is 29.5 t (of which 9.13 is electrical equipment) and the loaded weight is 36.5 t, with accommodation for 100 passengers (including 16 standing).



Plan SWP (Schindler).

Fig. 604. — Elevation and front view of the motor coaches, figures 602 and 603, Nos. 11-14, AOMC.

The builders are SLM-Winterthur for the mechanical parts and Oerlikon (MFO) for the electrical equipment. The first motor coach, No. 41, was put into service in the summer of 1954.

13) The railway from Königswinter to the Drachenfels, Drachenfelsbahn, operated by the Bergbahnen im Siebengebirge (Rhineland, near Bonn, right bank of the Rhine) was electrified in 1952/53 and the first electric motor coach was put into service on the 12th June 1953.

The line, using the now displaced steam traction, was brought into use on the 15th July 1883, and is consequently one of the first rack lines; it has a length of about 1.5 km (total ascent about 220 m) and is rack worked throughout (Riggenbach system) with a maximum gradient of 200 °/₀₀. The maximum speeds are 16 km/h on 160 °/₀₀ and 14 km/h on 200 °/₀₀.

The first electric motor coach has coachwork built by the railway itself, converting a former trailer vehicle which was worked with the motive unit on the lower side only, in each direction.

The electrical equipment (and the line equipment) was supplied by Brown-Boveri (Mannheim, Hess) and the transmission by Gmeinder of Moosbach. A new electric rack motor coach of high-capacity was to be ordered towards the end of 1954. These two coaches are fitted with a twin-commutator, trolleybus type, traction motor of the standard BBC type.

14) The Zugspitze Railway in the Bavarian Alps, Bayerische Zugspitzbahn, at Garmisch, was in 1953/54 in course of modernisation by the substitution (or addition) of electric motor coaches for its stock of electric locomotives.

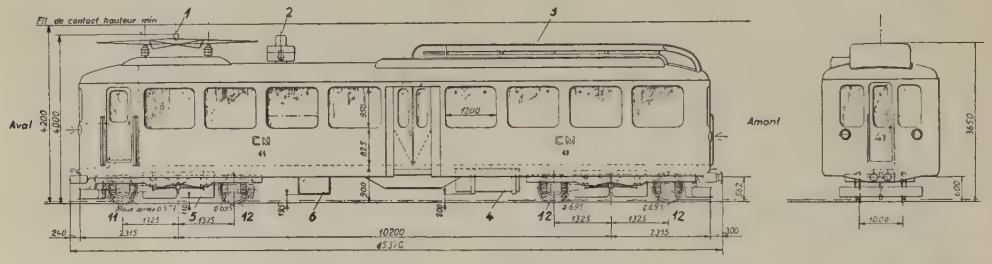
Previously the sets were hauled on adhesion (at the lower end of the line) by C type electric locomotives with three coupled axles, and on the rack (upper end of the line) propelled (or restrained on the downward journey) by rack locomotives.

We will return to the two items mentioned in **13**) and **14**) in the Supplement to *Vol. III.*

We will deal with modernisation of rack railways by Diesel motors at the end of Chapter VIII (Diesel traction).

motors (mainly diesel, but also flexible transmissions for gas or steam turbines (424) were mentioned in the sections dealing with the relevant mechanism. On page 6 of this *Volume III*, 1955, it was stated that transmissions for diesel traction would this time be allocated a separate chapter, No. VIII.

This was arranged because diesel traction is undoubtedly steadily increasing and because many lines, systems and countries, in Europe and overseas, are finding it advantageous to replace steam traction by internal combustion engines. Amongst the numerous exam-



Plan SLM 10-90348.

Fig. 605. — Dimensioned elevation and front view of the 1954 electric motor coaches of the Chamonix-Montenvers Railway, rack and adhesion.

1 = pantograph;
2 = earth;
3 = braking resistances;
4 = transformer;
5 = traction motors;
6 = accumulator battery;
11 = axle with combined drive;
12 = axle with rack drive only.

CHAPTER VIII.

HEAT ENGINES.

(INTERNAL COMBUSTION MOTORS OR TURBINES).

FOREWORD TO CHAPTER VIII.

In *Volume II*, 1950, some applications of individual drive by internal combustion

ples in the five continents, we are mentioning in note (426) only some of the more characteristic. No particular differentiation will be made, however, between the three methods of diesel traction (diesel-mechanical, diesel-hydraulic and diesel-electric) nor in the examples of turbo-diesel (or gas turbine) but we shall describe them, partly in this Chap-

(424) See, inter alia, *Vol. II* : p. 232, fig. 291 (*Congress Bulletin*, May 1949) regarding diesel-mechanical transmission; pp. 100-104, fig. 124-126 (and 347) and fig. 164-165, pp. 129-131, fig. 167-169 (*Congress Bulletin*, October 1948) regarding diesel-electric transmission; pp. 131 and 133, fig. 170-172 (*Congress Bulletin*, October 1948) and fig. 212*a* and 356, etc., regarding gas turbine locomotives, pp. 77-82, fig. 94-103 (*Congress Bulletin*, February 1948) and fig. 228-233, regarding steam turbines, high pressure steam turbines, etc.

(425) *Congress Bulletin*, February, 1953, p. 68.

(426) It is well-known that the large American (U.S.A.) railway companies have considerably, developed diesel (particularly diesel-electric) traction by the progressive introduction of very large multiple units, with large numbers of axles and considerable weight. The revue *Engineering* (U.S.A.),

ter VIII and partly in the Supplement at the end of this *Volume III.*

The replacement of steam locomotives by diesel traction (locomotives, railcars, multi-unit sets, tractors) is justified by some basic principles relating to *economy* in operation, viz :—

1) a steam locomotive is available for haulage during ten to twelve hours per day only (possible fifteen as a maximum) because of shed preparation (raising of steam to required boiler pressure, cleaning of grates, daily servicing, coaling and watering, etc.), whilst diesel engined vehicles can easily work eighteen to twenty hours per day;

2) a steam locomotive, cold, at the depot, needs one or even several hours before it can be made ready to haul a train, whilst a diesel machine can be put into service in five or ten minutes; in addition, the steam locomotive also consumes fuel, even when standing;

3) the average efficiency of a steam locomotive apart from the calorific value of the coal used is only in the region of 8 to 10 % (perhaps 12 % as a maximum) even in the case of modern superheated locomotives, of high-pressure, condensing or other types; the diesel motor on the other hand, has an efficiency three or four times greater than that of the steam engine (427).

Published works on diesel traction are numerous and we will mention only one work and some publications which are noteworthy and have contributed greatly over a quarter of a century to the spreading of information on diesel traction (428).

***

August, 1954 (and *R.G.C.F.*, November, 1954, p. 569) states that in 1954 there were in the United States 22 000 diesel-electric locomotives and that from 1955 to 1964, 8 000 diesel locomotives will replace 12 000 steam locomotives.

Various countries in Europe (apart from numerous cases in South America, the Middle and Far East, Africa, Australia, etc.) including the Netherlands, France, Germany, Spain, Italy, Belgium, Sweden, Denmark, Turkey, etc., have progressively introduced and developed diesel traction on non-electrified lines. Also Switzerland, which is almost wholly electrified, has recently started to replace steam traction, provided for reserve and emergency working, by diesel locomotives. In this connection, see *CFF Bulletin*, Berne, No. 2, 1955, « New diesel-engined vehicles of the Federal Railways », 3 p., 3 figs., E. Meyer (in French, German and Italian).

A typical case of operating economy on a local line is that of the Merzig-Büschfeld Railway (Saar) (« Merzig-Büschfelder Eisenbahn » MBE.) In this regard, see *E.T.T.*, No. 1-3, 1954, « Introduction of FNC/C 2-axled railcars on the Merzig-Büschfeld, MBE, Railway », 8 p., 4 figs., tables, W. Breitbach (in German and French). See also *R.G.C.F.*, May 1954, « Operation of Merzig-Büschfeld (Saar) line by light railcars », 3 p. with tables, same author.

(427) By comparison, the electric locomotive can at all times be put into service at once and its efficiency is noticeably higher, but here it is only a case of converting electrical energy into mechanical energy.

(428) See « Internal combustion locomotives and motor coaches », I. Franco and P. Labryn, Moorman's Periodieke Pers, The Hague, 1931.

This work, which is noteworthy and very complete for the period, with 235 pages of text and 185 figures, was translated in 1932 into French and German and published by Martinus Nijhoff, The Hague.

We may also mention the February, 1955, issue of *Diesel Railway Traction* (a *Railway Gazette* publication). This issue, No. 273, Vol. 8, is the Annual Review number; it comprises some 50 pages of text with 85 figures and accurately summarises what was achieved in diesel traction during 1954. We believe that *Diesel Railway Traction* was founded by Brian Reed, a specialist in diesel traction, who was at that time (more than 20 years ago) one of the editors of the *Railway Gazette*, London. Reed has had a considerable part in the development of diesel traction.

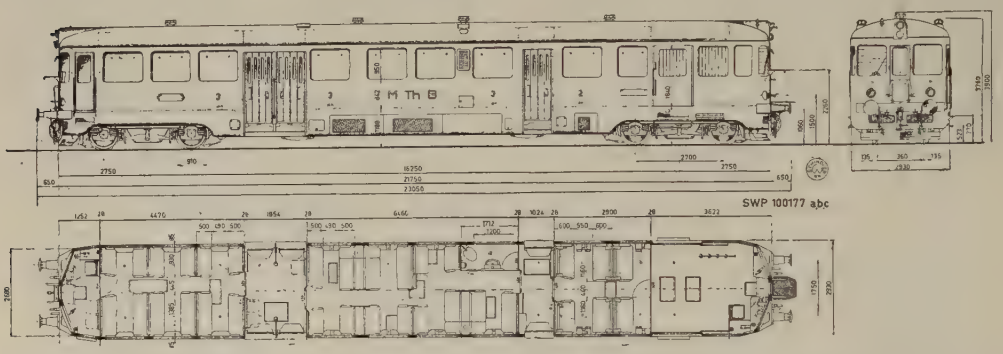
— See also the work mentioned in note (45) of *Vol. II*, « 20 000 Schriftquellen zur Eisenbahnkunde », Henschel, 1941, K. Ewald, particularly pages 584 and following.

— Finally, see the recent « Diesel locomotives », in four chapters, in *Congress Bulletin*, March, 1954, 20 p., 15 figs., U. Lamalle.

We will start with the 1951/54 railcars of the Mittel-Thurgau Bahn, MThB, Weinfelden, a line from Wil (St. Gall) to Kreuzlingen (near Constance) in North-East Switzerland.

These are diesel mechanical railcars, class BCFm$^2/_4$, Nos. 8 (1951), 7 and 9 (1954), with two bogies, each having one axle driven by the corresponding diesel motor, the two outer axles being carrying only. Figure 606 shows the railcar No. 8 in elevation, front view and plan, figure 607 the same car with a train in service, figure 608 the motor and transmission group with the bogie and figure 609 the bogie only.

Each of the two diesel motors has a continuous power of 200 HP and the railcar is therefore of 400 HP at a speed of 1 500 r.p.m.; one-hour rating (maximum) is 450 HP. Consumption is about 160-165 gr/HP/hour; each motor is equipped with two electric starters. The transmission to the inner axle of each bogie (E in fig. 608) is through a conical gear which also acts as a reversing gear. At each end of the actuating piston are two plate discs, permanently connected and linked to the axle by a flanged coupling, electro-pneumatically operated when at rest, for both motors together, from the driver's position.



Plan Schindler SWP 100 177 c.

Fig. 606. — Diesel cars, Nos. 7, 8 and 9 (elevation, front view and plan) of the MThB, Switzerland.

Fig. 607. — Diesel set of the MThB Railway at Weinfelden station. Motor coach No. 8 (fig. 606) leading, followed by a trailer (old type coach modernised and rebuilt after being damaged) with motor coach No. 7 in the rear. The overhead contact wire is that of the Swiss Federal Railways (Winterthur - Frauenfeld-Romanshorn line) which crosses the MThB at Weinfelden.

Photo Nuber, Weinfelden.

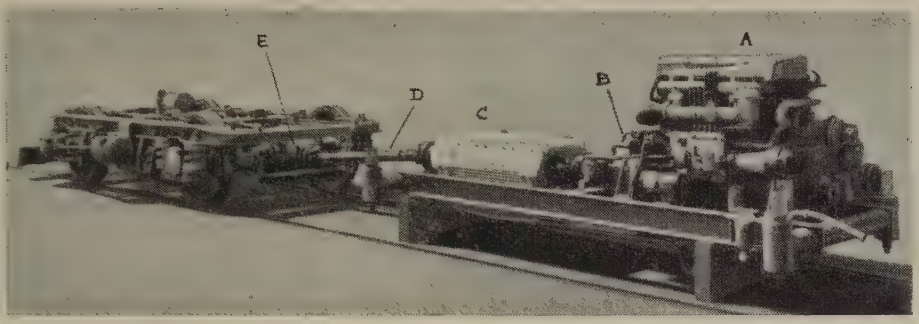


Photo SWP 436B.

Fig. 608. — Motor-transmission-bogie group of the motor coaches in figures 606 and 607. The motor-transmission groupe, A-B-C are suspended under the coach body to avoid the transmission of vibration to the coach frame.

A = Saurer DXDL motor (high-compression) 200 H.P. continuous.
B = Hydraulic coupling.
C = Transmission, 8 speeds and neutral, Saurer type.
D = Cardan shaft.
E = Axle drive, with reverser.

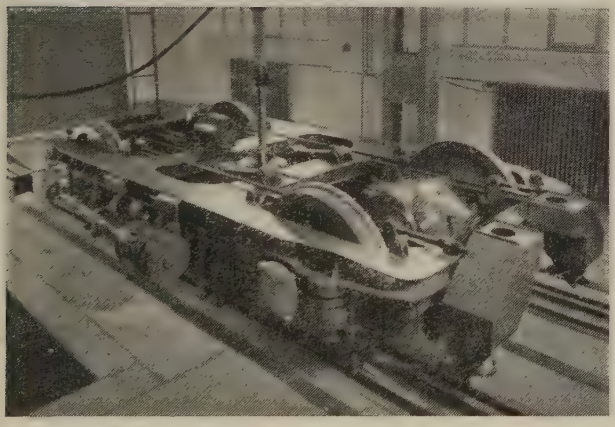


Fig. 609. — Bogie of motor coaches, figures 606-608, on a works test bed, for examination of deflection in suspension (endless screw working on bogie pivot). On the right hand axle (between the wheels) is the transmission gear box (E of fig. 608).

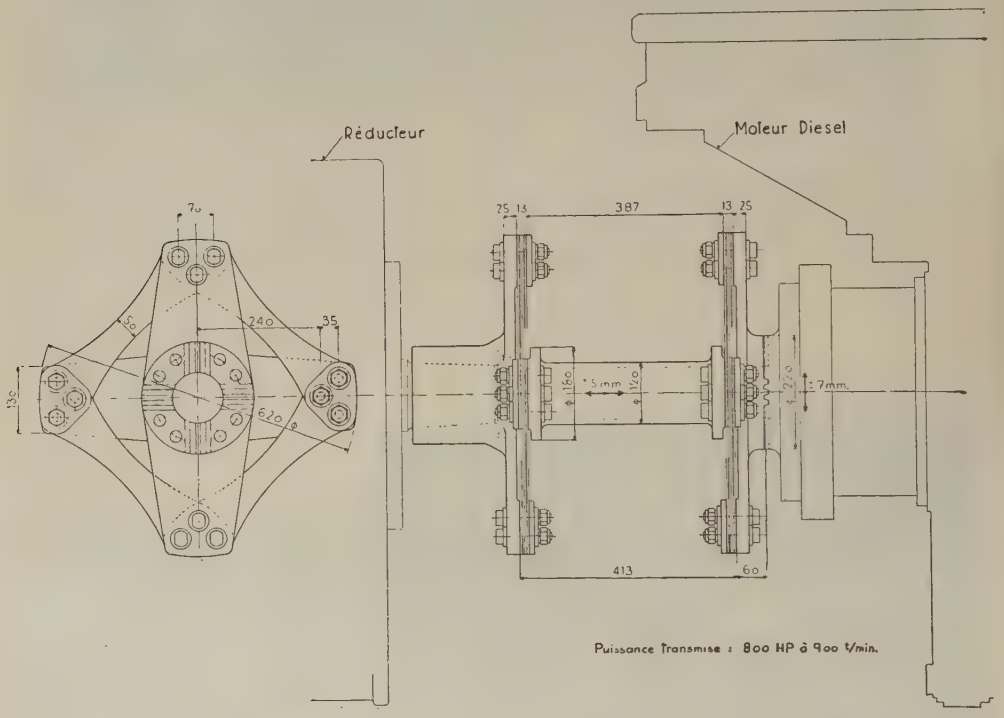
Photo SWP 446.

The tare of these railcars is 41 tons, 32 tons of which is for the coach and bogies. The normal speed in service, on level track, is 70-75 km (43-46 miles)/h (429). The manufacturers were the SCHINDLER Waggon Co. (SWP) of Pratteln for the coach work and the ADOLPH SAURER Co. of Arbon (Lake Constance) for items A to E of figure 608.

On *eight* diesel-hydraulic locomotives

(429) See *Diesel Railway Traction (Gazette)*, London, November, 1952, « Swiss Standard Gauge Railcar », 3 p., 5 figs.

delivered in 1954 by the Ateliers et Forges de la Loire (France) to the Dakar-Niger Railway (Senegal, West Africa) the Secheron type leaf-spring coupling (430) has been used to connect the SULZER coupled axles, supplied in 1954 to the Spanish State Railways, RENFE, by HENSCHEL & SON, Kassel, and KRAUSS-MAFFEI, Munich-Allach, Germany. These machines, shown in fig. 611,



Plan SAAS D 362 369.

Fig. 610. — SECHERON leaf-spring transmission coupling connecting the Diesel motor and hydraulic transmission of 8 diesel locomotives of the Dakar-Niger Railway, also used on the machines in figure 611.

6 LDA 25 motor to the VOITH L 36 hydraulic transmission. Figure 610 shows this coupling. A similar coupling has been used on *twenty* diesel locomotives, series 10 501, type D, with four rod-

have the following characteristics : 550 HP, SULZER diesel motor, type 6 LDA 22, VOITH L 37 transmission (hydraulic).

The leaf spring coupling shown in figure 610 thus serves in these two cases

(430) Cf. fig. 524, 525, 534, 540, etc. — See *E.B.*, October, 1954, p. 260, fig. 23.

not as a transmission to the axles but only as a flexible link between the diesel motor and the transmission (431).

Before passing to other locomotives or sets of special types we may describe briefly the transmission of two new light-weight trains of the German Federal Railways, DB, — prototypes of an entirely new design — put into normal service after a long period of trial, in 1954, which were shown to the public for the

Photo Henschel.

Fig. 611. — Diesel shunting locomotives, with four coupled axles, series 10.501, of the Spanish RENFE. The link between the Diesel motor and the hydraulic transmission is by the Secheron leaf spring and cardan shaft mechanism shown in figure 610.

Photo Wegmann.

Fig. 612. — Lightweight, articulated, Diesel-mechanical set, with coachwork of light metals, 8 bogies, series VT. 10.551 (sleeping car set) of the German Sleeping and Restaurant Car Co. DSG. The day set, DB. VT. 10.501 is similar in external appearance. In the front can be seen the automatic Scharfenberg coupling for connecting two or more sets together.

first time at the Transport Exhibition in Munich in 1952. These are *articulated* sets of seven units, built of *light alloys*; one a day-service set series VT. 10.501 of the « Deutsche Bundesbahn » DB and one a night-service set (mainly sleeping cars) series VT. 10.551 of the DSG (Deutsche Schlafwagen und Speisewagen Gesellschaft) (432). Figure 612 shows the

(431) See, in addition to the publication in note (430) : *Glasers Annalen*, Berlin/Bielefeld, August, 1954, « The 550 HP diesel locomotive of the RENFE, type D, for train haulage and shunting » (in German), 11 p., 19 figs., tables, Gössl and Nürnberger.

(432) A detailed description of the two sets (and the reasons for their construction) appeared in 1953, in a series of articles, as under :

— *Die Bundesbahn*, Frankfurt/Main, No. 12, « Gliederzüge für den Fernverkehr », E. Frohne, First President of the German Railways DB.

— *Eisenbahntechnische Rundschau ETR*, Frankfurt/Main, No. 6/7, « Vom Schienenzeppelin zum Gliedertriebzug », Kruckenberg.

— Same edition of *ETR*, « Die neuen Leichtmetall-Gliedertriebzüge », Leicher.

— *Aluminium*, Düsseldorf, No. 6, « Aluminium als Werkstoff für die neuen Leichtmetall-Gliedertriebzüge », Bleicher and Szymanski.

— *Aluminium im Verkehr*, Aluminium Zentrale, Düsseldorf, « Konstruktion eines Reise-Gliedertriebzuges aus Leichtmetall », Augenstein.

— *Glasers Annalen*, Berlin, No. 6/7, « Konstruktive und fertigungstechnische Erfahrungen bei dem Bau eines Schlafwagen-Gliedertriebzuges », Bode.

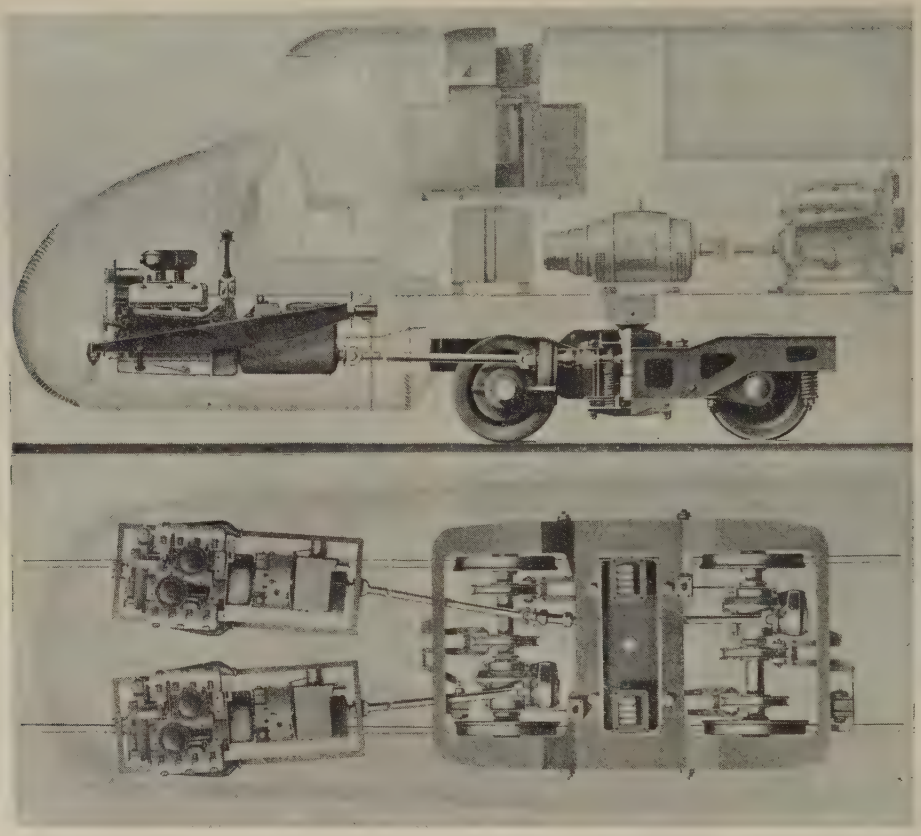


Photo MAN.

Fig. 613. — Leading portion (at each end), in plan and elevation, of the sets in figure 612, showing the arrangement of the motor, transmission and driving bogies. On the bogie can be seen the brake drums. Each of the diesel motors drives one axle.

Continued to (432).

— Same issue, *G.A.*, « Neue Wege für die Ausbildung von Maschinenanlagen und Laufwerken von leichten Gliedertriebzügen », MÖLBERT.

— Same edition, *G.A.*, « Die Stromversorgung der Leichtmetall-Gliedertriebzüge », BAUR.

— Same issue, same author, « Die Beleuchtung der Leichtmetall-Gliedertriebzüge ».

— Same issue, same author, « Die Klimaanlagen der Leichtmetall-Gliedertriebzüge ».

N. B. — All these articles have been collected into one brochure of a hundred pages or so, with 136 figures and diagrams, with numerous tables, entitled « Leichtmetall-Gliedertriebzüge », published by *Glasers Annalen*, Berlin, edition WELZ.

— See also, *L'Industrie des Voies Ferrées et des Transports Automobiles*, Paris (organ of the Union des Voies Ferrées de France, UVF), February, 1955, « New German articulated sets of light metals » (in French), 18 figs., Ad. M. HUG.

night set on the line. The extreme bogies, which are the same for the two sets, are two-axled, driving (see fig. 613, mechanical transmission only); on the other hand, the intermediate bogies under the articulations are single axled on the day set (fig. 614) and two axled on the night set, which is heavier because of the provision of sleeping cars. Each of the two sets has four diesel motors, two of which are located in the two bonnets at the ends of the train; the power of $4 \times 160 = 640$ HP will be increased to $4 \times 210 = 840$ HP when the superchargers have been fitted. The maximum speed in service will then increase from 120 to 160 km (74 to 100 miles)/h. The tare of the sets, which have multi-unit drive equipment (AEG/EMG) is about 89 tons for the day set and 98 tons for the night set (first type with seven units); the weights in working order are 94 and 103 tons respectively.

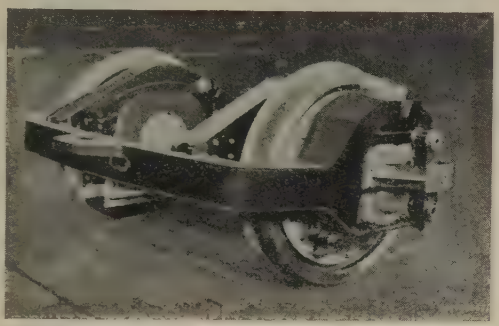


Photo MAN.

Fig. 614. — Single-axle bogie, MAN type, for use under the articulations of the day service set (as fig. 612), DB, series VT. 10.501.

These sets, the bodies of which are built entirely of aluminium alloys were constructed by LINKE - HOFFMANN-BUSCH (DB day set) and by WEG-

Fig. 615. — German Federal Railways road-rail bus. This shows the registration plate for road use.

Photo NWF-Wilhelmshaven.

(433) In 1954/55 this night set, after a trial period, was increased in capacity by the addition of a new intermediate coach which increases the number of units from 7 to 8.

Fig. 616. — Main line diesel locomotive, B'B' type, series V 200.001, 2000 HP, 140 km/h of the German Federal Railways, hauling a train over an electrified line.

Photo Krauss-Maffei.

MANN (DSG night set); the driving bogies with transmission are all by MAN, Nuremberg, as are the single-axle bogies; the two-axled carrying bogies of the night set are Wegmann type.

Whilst dealing with German railcars, we may mention briefly a type of light-weight railcar having the feature that it can work as a railcar on the railway line and also as a road omnibus. Figure 615 shows this coach on the railway line, with the leading pneumatic-tyred wheels raised. The rear pneumatic-tyred axle is used for traction (adhesion) on rail and road. The flanged wheels, which are carrying, fold externally and remain in position inclined at about 30° when the vehicle is working as a road bus.

This railcar, which is known as the Schi-Stra-Bus (from Schiene = rail, and Strasse = road) was built by the « Nord-westdeutscher Fahrzeugbau », NWF, of Wilhelmshaven. It has a power of 130 HP with five forward and two reverse speeds, the diesel motor working at 2 250 r.p.m. The tare is 12 tons, the loaded weight 16 tons; maximum speed: 105 km (65miles)/h. The overall length is 11.08 m, the total width 2.5 m and the height 2.88 m.

We now pass to locomotives.

The German Railways, DB, which

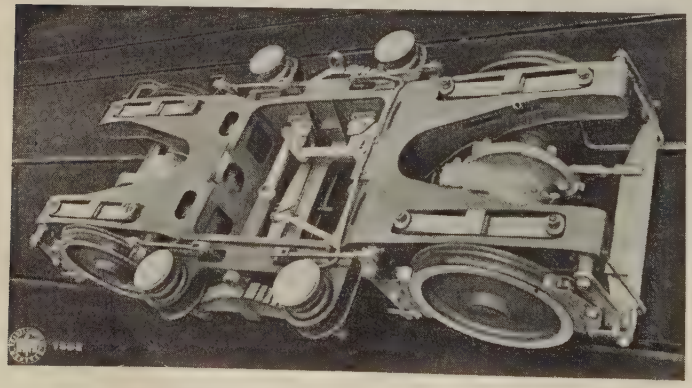


Fig. 617. — Bogie of the locomotive in figure 616. This shows the casing over the conical gears on each of the two axles. Standard type suspension and brakes.

Photo Krauss-Maffei.

were, as we know, amongst the first to use diesel motors for locomotives (434) put into service in 1953 two types of B'B' diesel locomotives, with 4 axles and hydraulic transmission, the transmission to each of the axles being through cardan shafts in the bogie, i.e. :

Photo Krauss-Maffei.

Fig. 618. — Diesel locomotive for light trains or heavy shunting duty, type B'B', series V. 80.001, 800-1 000 HP, 50/100 km/h German Federal Railways.

a) five locomotives, series V 200, Nos. .001 to .005, 2 000 HP (figs. 616 and 617) for hauling express trains, maximum speed in service 140 km (87 miles)/h in either direction (435), 1953;

b) five locomotives, series V 80, Nos. .001 to .005 (figs. 618. 619 and 620) for hauling light trains or for heavy shunting work, maximum speed in service 100 (or 50) km (62 [or 31] miles)/h in either direction (436), 1952.

These two types of locomotives were built by KRAUSS-MAFFEI of Munich-Allach. The machines in *a)* have two 1 000 HP diesel motors each (1 500 r.p.m. Maybach and Daimler-Benz) and those in *b)* a single motor (Maybach, 1 000 HP, 1 500 r.p.m. or MAN 800 HP and Daimler-Benz 1 400 r.p.m. (437).

The transmission is hydraulic in both

(434) The first diesel locomotive (which was driven directly from the diesel motor with the crank forming a false axle driving the two motor axles by coupling rods) was of 2-B-2 type; it was built in 1911 by and for the Prussian State Railways, in collaboration with Sulzer Bros, Diesel and Klose. For starting (which was very slow) it was necessary to assist with compressed air until the speed was up to about 25 km/h. The main features were as follows : power 1 000-1 200 HP, length overall 16.6 m, weight in working order 95 tons, maximum speed 100 km/h, diameter of driving wheels 1 750 mm. In this respect, see *Glasers Annalen*, Berlin, 1/12/31, « Über Diesellokomotiven unter besonderer Berüksichtigung der Versuchsergebnisse der Dieseldruckluftlokomotive der Deutschen Reichsbahn », 7 p., 11 figs. and diagrams, H. Nordmann. See also Franco-Labryn (428).

The first diesel railcar was, so far as we are aware, one with electrical transmission, built in 1914 by and for the State Railways of Saxony. Then came the Soviet-Russian (Lomonosow) diesel-electric locomotive, also built in Germany.

(435) See *Die Bundesbahn*, published by the Central Office of the DB, No. 13/14, 1953, « Die 2 000-PS-Diesellok der Deutschen Bundesbahn (Baureihe V 200) mit hydraulischer Kraftübertragung », 9 p., 12 figs. and tables, G.A. Gaebler.

— See also *Eisenbahntechnische Rundschau ETR*, Cologne/Darmstadt, No. 6/7, 1953, « Die 2 000-PS-Diesellokomotive der Deutschen Bundesbahn », 14 p., 18 figs., tables, C. Lampe and N. Gössl.

— See also, same review *ETR*, No. 6, 1954, « Die neue Grossdiesellokomotive der Deutschen Bundesbahn, Baureihe V 200, im Regeldienst », 1 p., 1 fig., F. Flemming.

— Finally, see *Industriekurier*, Nos. 130, 27/8/53 and 152, 8/10/53, « Attraktive Eisenbahn-Verdieselung », a total of 4 p., 1 fig.

(436) See *Glasers Annalen*, Berlin/Bielefeld, No. 4, April, 1952 (76th. year), « Die 1 000-PS-Diesellokomotive der Deutschen Bundesbahn für leichten Strecken- und schweren Rangierdienst », 15 p., 23 figs. and tables, C. Lampe and E. Pflug.

— See also, *Diesel Railway Traction (Gazette)*, November 1952, « German Diesel-Hydraulic Bogie Locomotives », 3 p., 3 figs.

(437) The V 80 locomotives were at first fitted with a 800 HP motor which was later replaced, at the request of the Railway Company, by a 1 000 HP motor.

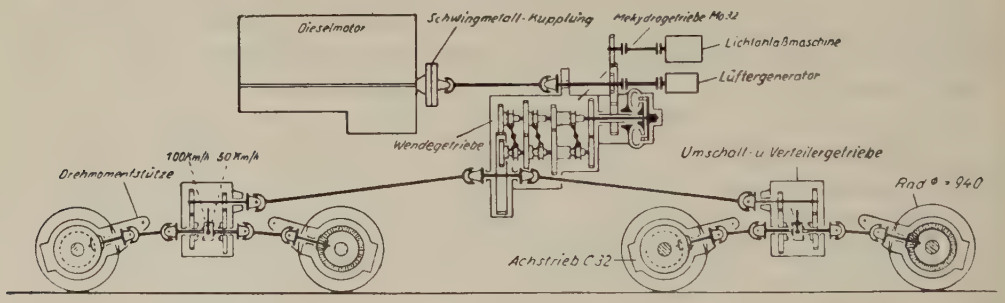
cases, Maybach Mekydro (K.104, US) for the machines under *a)* and VOITH (T.36) or Maybach-Mekydro for the machines under *b)*. The drive on the axles is similar in both cases, by conical gears in which the pinion is driven by cardans. For the machines under *a)* the arrangement of the drive is the same as in figure 620 except that each motor drives only the two axles of one bogie with the speed selector for operating at either 100 or 50 km/h according to the type of service to be worked.

Detailed descriptions can be referred to in the publications mentioned in the footnotes and further mention will be made of them in the Supplement.

We will now pass to the French turbo-diesel, designed and built by the RENAULT Works at Billancourt, near

Fig. 619. — Bogie of locomotive, figure 618.

Photo Krauss-Maffei.



From *Glasers Annalen*.

Fig. 620. — Diagram of the motor-transmission-drive of locomotive in figures 618 and 619. On each bogie there is a gear box for 50 or 100 km/h according to the type of service required. A single diesel motor drives the 4 axles. Apart from the gear boxes, the diagram also serves for the locomotive in figures 616 and 617, except that there is a 1 000 HP diesel motor for each of the two bogies.

Schwingmetall-Kuppling = flexible metal joint. — Mekydrogetriebe = Mekydro transmission. — Lichtanlassmaschine = lighting dynamo. — Lüftergenerator = generating ventilator. — Wendegetriebe = reverser. — Umschalt- und Verteilergetriebe = speed changer (50-100 km/h). — Drehmomentstütze = turning moment chock arm. — Achstrieb = turning moment chock arm. — Achstrieb = axle drive. — Rad ø = wheel diameter.

Paris, and which bears the S.N.C.F., number 040-GA-1. This is a B_0-B_0 type locomotive, gas turbine with free piston generator, giving a high efficiency for a combustion engine (overall efficiency of the generator-turbine-reducer group, 33%) which thus provides a particularly important advance for railway traction.

This locomotive, designated R.N.U.R. 507 or 5 070 has a power of 1 000 HP with two ranges of speed (71 or 125 km (44 or 77 miles)/h and was put into service experimentally in 1952 ([438]). It has for a long time been working a daily service of 414 km on the Paris-Cambrai line of the S.N.C.F. (standard gauge).

This, too, is not really an individual drive, since the four axles are driven by one gas turbine through cardan shafts working directly on the two inner axles and indirectly on the two outer axles, an arrangement which is fairly similar to those on other locomotives and multi-unit sets already described. The *transmission* is, moreover, purely *mechanical* since the machine is set in motion by a group comprising a SIGMA gas generator with free pistons (model GS-34) and a Rateau 1 000 HP turbine with reducer.

The principle characteristics of the Renault turbo-diesel locomotive for standard 1 445 mm gauge, with two driving pistons, are as follow :

Overall length	16.18 m
Width	2.72 m
Total height	4.22 m
Distance between bogie pivots	9.0 m
Bogie wheelbase	2.6 m
Wheel diameter (tread)	0.9 m
Weight in working order (axle load)	62 tons (15.5 approx.)

Figure 621 shows the locomotive in service, figures 622 and 623 the driving bogie (two similar bogies) and figure 624 a driving axle. Finally, figures 625 and 626 respectively show the dimensions and the interior arrangement, and the front view with five different cross-sections. After this brief description — the transmission mechanism being visible in the longitudinal section in figure 625 — we shall return to the subject of the results obtained during its three years of service and also describe its special features in the Supplement, when two types of RNUR *diesel-hydraulic* locomotives for metre-gauge lines will also be dealt with.

Still dealing with turbine locomotives, we may mention in connection with locomotive No. 6 200, 1945, of the Pennsylvania Railroad (figs. 94 to 97 of *Vol. II*) ([439]), the steam turbine locomotive with electrical transmission, type C_0-C_0 + C_0-C_0 + tender, No. 2 300, of the Norfolk and Western Railroad ([440]). This

([438]) See *R.G.C.F.*, May, 1952, « A new gas-turbine locomotive with free-piston generator » (in French), 10 p., 13 figs. and diagrams, F. Picard.

— See also *Diesel Railway Traction (Gazette)*, August, 1952, « Gas-generator locomotive in France », 2 p., 2 figs.

([439]) *Congress Bulletin*, February, 1948.

([440]) See *Modern Railroads*, USA., July, 1954, also the note, with an illustration of the machine, in *R.G.C.F.*, January, 1955, p. 52. This article has been analysed by the Documentation Office of the S.N.C.F. in a note attached to the U.I.C. Documentation Bulletin, October, 1954.

Fig. 621. — Renault turbo-Diesel locomotive, No. 040-GA-1, SNCF, hauling a goods train.

Photo R.N.U.R. (Renault).

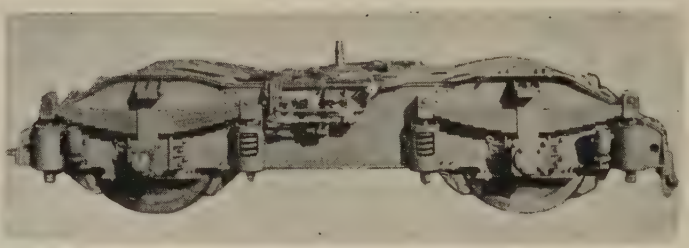


Fig. 622. — Side view of one of the driving bogies of the locomotive in figure 621.

Photo R.N.U.R.

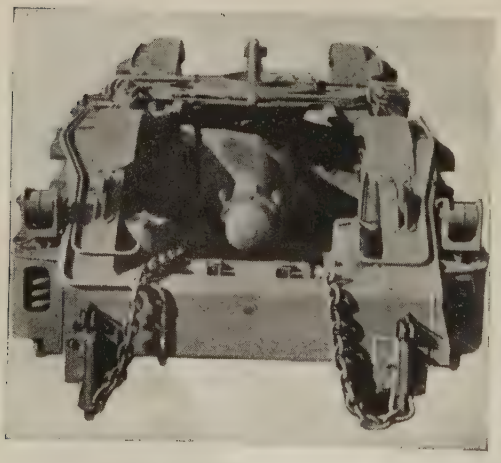


Photo R.N.U.R.

Fig. 623. — Front view of the bogie in figure 622.

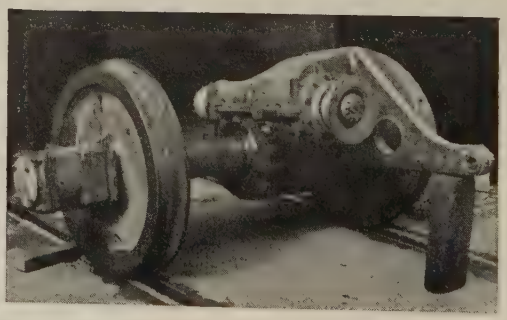
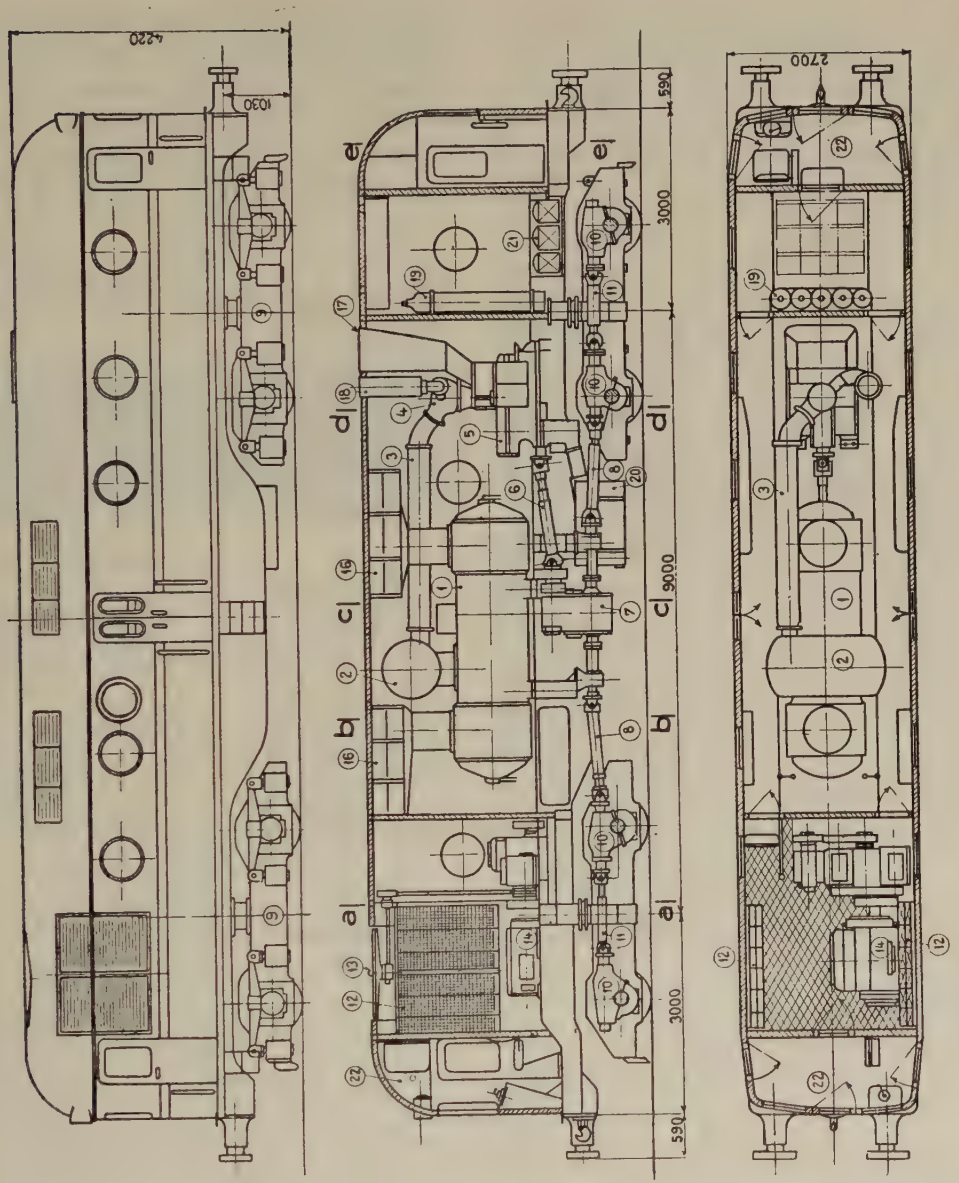


Photo R.N.U.R.

Fig. 624. — Driving axle of locomotive in figures 621-623.



From *R.G.C.F.*

Fig. 625. — Elevation, section and plan of the locomotive in figures 621-624. The bottom part of the section clearly shows (as does the section *aa* of figure 626) the transmission to the axles and to the gas turbine (5), through (6), (7), (8), (10) and (11). A key to the numbering is included in figure 626.

machine is of exceptional size (even for the American Railways) since it weighs with its tender 532 tons and has a length of 49.11 m. The locomotive has four bogies with three driving axles, each axle having a load of 30 tons. The fuel (20 tons of small 50 mm coal) is carried on the front of the locomotive; the tender, which is on two three-axled bogies, conveys water only (83 m^3). The boiler pressure is 42 kg/cm^2 with a steam temperature of 482° C. The Westinghouse turbine, running at 8 000 r.p.m. drives at 4 500 HP the generator feeding the 12 traction motors. There is no condensor. There is an automatic arrangement for filtering the feed water and for extracting non-soluble solids. It is considered that because of the high-pressure and the present prices of coal and fuel oil, this machine will give economic results comparable with those given by diesel-electric units of the same power.

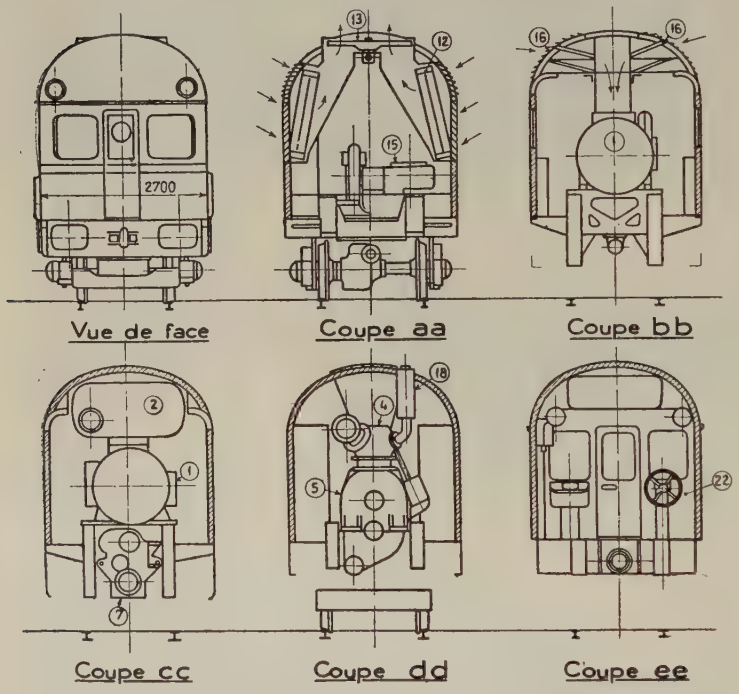


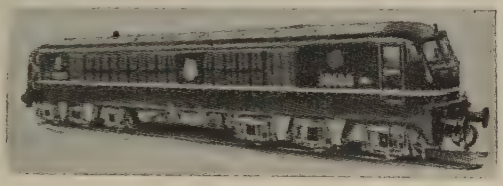
Fig. 626. — Front view and cross sections of the locomotive in figures 621-625.

1 = gas generator.
2 = gas reservoir.
3 = gas feed pipe.
4 = by-pass.
5 = gas turbine.
6 = transmission from turbine to central block.
7 = central transmission (reducer, speed restrictor and changer).
8 = transmission to axles.
9 = bogie.
10 = drive.
11 = transmission between axles.
12 = radiators, oil and water.
13 = ventilator.
14 = auxiliary diesel motor.
15 = servo-compressors (water and oil pumps), dynamo, electric motor.
16 = roof-mounted air filters.
17 = turbine exhaust.
18 = exhaust by-pass.
19 = air cylinder for starting.
20 = turbine oil tank.
21 = accumulators.
22 = driving position.

From *R.G.C.F.*

We may now mention, with a reservation that they will be further dealt with in the Supplement *(Vol. III)*, the *gas-turbine* locomotives, series 18 100, shown in figure 627, type C'_0-C'_0, with electric transmission (nose-suspended mo-

tors) of the Western Region of British Railways (441) developing 3 000 HP continuous rating, built by Metropolitan-Vickers, maximum speed 145 km (90 miles)/h, overall efficiency in full use 15.5%. We have already mentioned in *Vol. II* the gas-turbine locomotives, series 18 000, type A1A-A1A of the same Region of British Railways, also with electric transmission, by Brown Boveri,



Metrovick.

Fig. 627. — C'_0-C'_0 gas turbine locomotive of British Railways, Western Region, series 18 100, 3 000 HP, 145 km/h 1951.

with four flexibly hung motors developing 2 500 HP, 145 km/h (442).

With regard to French *diesel-electric* locomotives, we may mention in passing the machines, series 030-DA (443) and 040-DE (444) of the S.N.C.F., fitted with nose-suspended electric motors, built by the Brissonneau and Lotz Company, of Nantes and Creil; some features of these will also be mentioned in the Supplement.

With regard to diesel *multi-unit sets* in France, there are, so far as we are aware, no recent introductions, but there are some true diesel railcars (large or small cars, often with a trailer coach). We may mention briefly, subject to returning in the Supplement *(Vol. III)* to some most interesting introductions, that the new diesel railcars of the S.N.C.F. (and of systems in other countries, of differing gauges) have overall lengths up to 27.5 m (about 52 m with a four-axle trailer). These are four-axle railcars, either of 300 HP (one diesel motor) or of 600 HP (two motors) constructed by Renault, de Dietrich, Aciéries du Nord, Bugatti, Decauville, Brissonneau and Lotz, etc. (445). All these diesel railcars have an

(441) See *Gazette*, 1st. February, 1952, *Diesel Railway Traction*, March, 1952, and *R.G.C.F.*, September, 1952, pp. 415-417, Brun.

— *Congress Bulletin*, October, 1952, « British built gas turbine locomotive », 12 p., 10 figs. including a large plan.

(442) *Vol. II*, pp. 277-278, figs. 212*a* and 356 (*Congress Bulletin*, November, 1949).

(443) See *R.G.C.F.*, October, 1950, « Diesel-electric shunting locomotives, 500 HP, series 030DA, of the S.N.C.F. », 8 p., 9 figs., tables, Tourneur.

— With regard to the French diesel-mechanical locomotives, one-metre gauge (and normal, 4-axled) for local lines, see *R.G.C.F.*, September, 1950, « Les locomotives diesel pour l'exploitation des lignes secondaires », 10 p., 14 figs., tables, Zens and Honnoré; also *Diesel Railway Traction (Railway Gazette)*, « Light-Railway locomotives in France », 2 p., 2 figs., P. Zens.

(444) See *R.G.C.F.*, April, 1953, « New diesel-electric locomotives, series 040-DE, of the S.N.C.F., 10 p., 10 figs. and diagrams, tables, Bauvin and Olive.

(445) See *R.G.C.F.*, September, 1954, « Eléments automoteurs diesel pour relations à grands parcours », 16 p., 17 figs., Despouy (S.N.C.F.).

— See also *L'Industrie des Voies Ferrées et des Transports Automobiles*, Paris, January, 1955, « Les nouvelles rames automotrices diesel de la S.N.C.F. », 8 p., 14 figs., Despouy. This deals with the sets which have since May, 1954, been progressively introduced in the Lyon-Bordeaux, Lyon-Geneva, Bordeaux-Toulouse, Lyon-Strasbourg, Paris-Clermont-Ferrand and Paris-Saint-Etienne-Lyon services.

— See also *R.G.C.F.*, September, 1953, « 600 HP standard railcars of the S.N.C.F. » (in French), 16 figs. and diagrams, tables, Despouy; also same review, same author, September, 1952, « 300 H.P. standard railcars of the S.N.C.F. », 7 p., 9 figs., and *Diesel Railway Traction (Gazette)*, August, 1954, « French express twin sets », 2 p., 3 figs.

arrangement of the drive similar to that in figures 608, 613, 617, 620, 625-626, etc.

In the Scandinavian countries, the Danish State Railways, DSB, have also been amongst the first to introduce diesel traction. We mentioned in *Vol. II* p. 14, (fig. 10) the diesel-electric locomotives, series 131, type 2-D_0-2 ([446]) and will describe in the Supplement *(Vol. III)* the express diesel multi-unit sets for the main lines of the DSB. We will mention at the same time, the diesel locomotive of the Norwegian Railways, NSB and also — in connection with the SAB resilient, rubber-mounted wheels — of the numerous new diesel railcars of the Swedish State Railways, SJ (already mentioned in several places).

We will now revert to the British Railways and first mention briefly the diesel hydraulic reversible sets, the first two of which were shown on the 29th. April, 1954, at Marylebone Station, London; they are designed to operate lightly-loaded passenger services in six different areas and will be made up of either two railcars or one railcar and one trailer. *Light alloys* have been extensively used in the construction of the body and the complete set of driving coaches (two) weighs only 55 tons in working order. Each car develops 250 HP by two 125 HP omnibus motors of current type. Each car is mounted on two bogies of which one axle is driven through a torque-converter, Leysholm-Smith (Leyland) type, and a five-speed gearbox ([447]).

We now pass to the « Fell » diesel-mechanical locomotive, No. 10 100, type 2-D-2, built 1950/51, in the Derby locomotive Works ([448]). This is a main-line locomotive, 2 000 HP, with four diesel motors having a new method of boosting; maximum speed 125 km (75 miles)/h.

This machine, too, has no true individual axle drive since the four driving axles are rod-coupled, but the two middle driving axles have — in order to make the transmission flexible and to reduce the unsprung weight — their wheels fitted with a rubber-mounted « quill-cup » drive. This can be compared, in certain respects at least, with the steam turbine No. 6 200 of the Pennsylvania Railroad in the U.S.A. [see note ([439])]. Whilst the latter has wheels of the normal steam locomotive type (see figs. 96 and 97 of *Vol. II*) and the cup drive in the main gear wheel of the transmission; the Fell locomotive has driving wheels fitted

([446]) *Congress Bulletin*, September, 1947. — See also *Diesel Railway Traction (Gazette)*, July, 1953, « Diesel Development, Danish State Railways », 5 p., 8 figs.

— With regard to the « Lyntog » sets, see also the same publication, March, 1953, p. 68, and with regard to the new locomotives from the Frichs Works, the April, 1953, edition, p. 76.

— With regard to the most recent Danish machines, type A1A-A1A, 1 500-1 750 HP, which will be further mentioned in the Supplement of *Vol. III*, see *Diesel Railway Traction (Gazette)*, « Main Line Locomotives for Denmark », 10 p., 7 figs.

([447]) See *Gazette* of the 7th. May, 1954, and *Modern Transport*, London, 8th. May, 1954.

— See also *R.G.C.F.*, October, 1954, « Nouveaux éléments diesel légers des Chemins de fer britanniques », 1 p., 1 fig., P. PATIN, and *Diesel Railway Traction (Gazette)*, July, 1954, « British Diesel Hydro-mechnaical Trains », 4 p., 5 figs.

([448]) See *Diesel Railway Traction (Gazette)*, July, 1951. — See also *Congress Bulletin*, September, 1952, 11 p., 9 figs. This machine was designed by H.G. IVATT, Chief Mechanical Engineer of the London Midland Region, BR, and built in conjunction with Fell Developments Ltd.

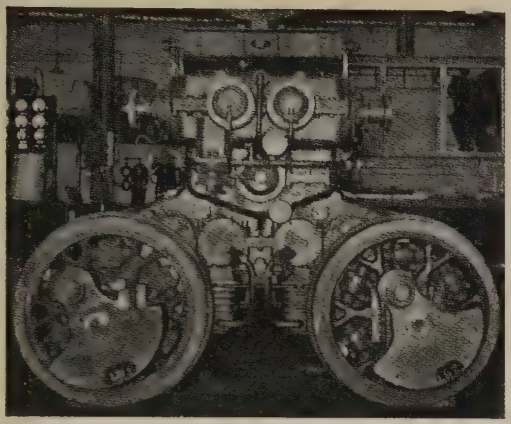
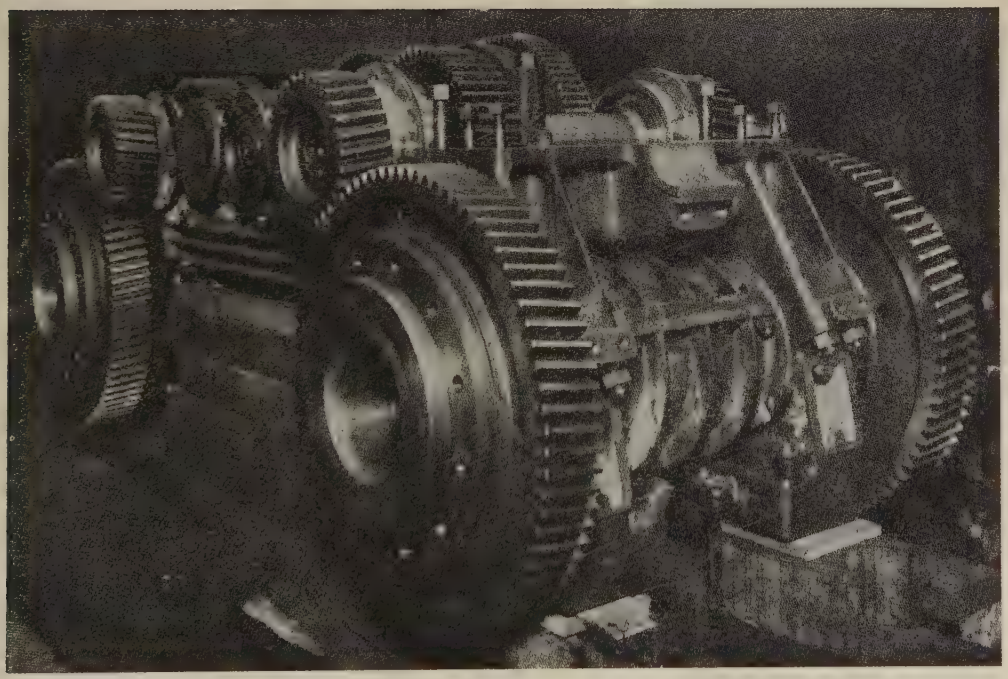


Fig. 628. — The two central driving axles of the « Fell » locomotive (fig. 630 and 631) are driven from the hollow shafts (mounted in the gear boxes, fig. 629) by a rubber-mounted cupped-quill drive. (Cf. fig. 68, 70, 76, 81, 89, 97, 100, 106, 298, 299, 301, 304, 322-324, 325 of *Vol. II.*)

From *Congress Bulletin.*



From *Congress Bulletin.*

Fig. 629. — The two hollow shafts in the central transmission group, with their gears and pinions for final transmission. The two hollow shafts encircle the central axles shown in figure 628.

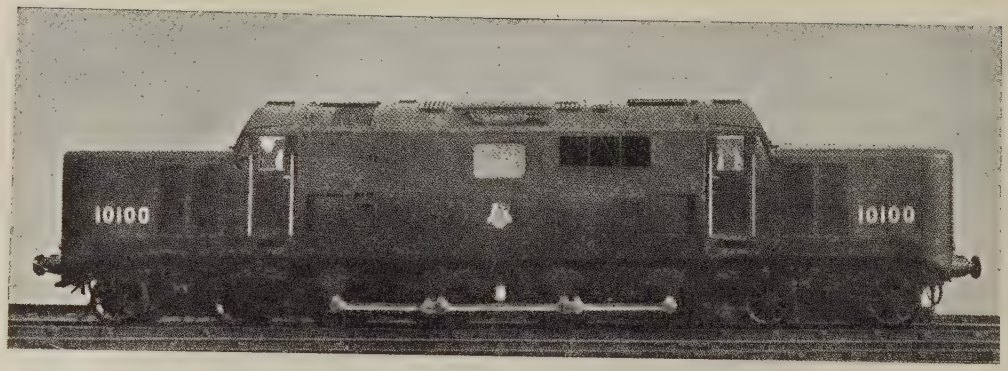


Fig. 630. — Main line Diesel electric locomotive, type 2-D-2, No. 10100, of British Railways.

From *Congress Bulletin.*

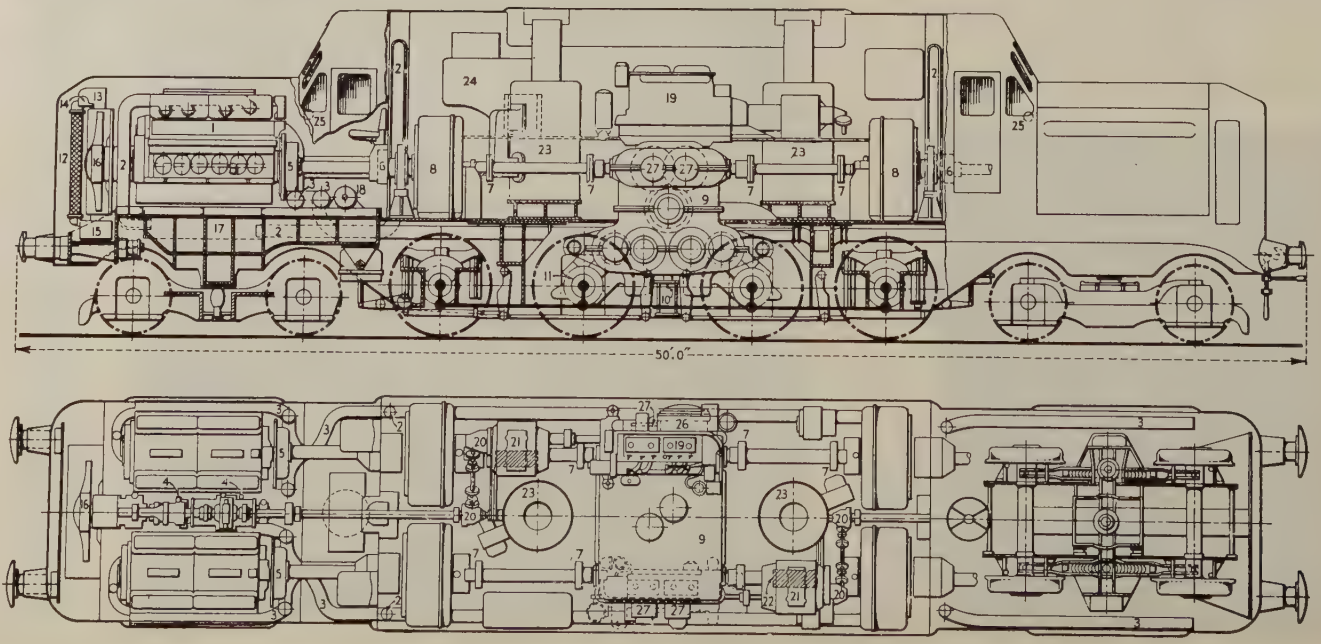


Fig. 631. — Elevation with part section and plan of the « Fell » locomotive in figure 630. For key to component parts, see the publications mentioned in note (448).

From *Congress Bulletin.*

with cup drive similar to that of S.N.C.F. locomotive No. 232-Q1, of 1939, with individual steam turbine drive [see figs. 98 to 103 of *Vol. II* (449)]. The arrangement can be seen in figures 628, 629 and 631. Figure 628 shows the two central driving axles surmounted by the transmission and figure 629 the two corresponding hollow shafts. Figure 630 shows the locomotive ready for service, figure 631 the complete locomotive in elevation and plan. This machine was also shown at Marylebone, London (23rd. May, 1951).

As mentioned in the middle of note (426), the Swiss Federal Railways, SBB-CFF-FFS, whose system is almost wholly electrified, have for the past few years had a programme of self-motored vehicles (motor coaches) for working on small sections of line not yet electrified and also for reserve and emergency services (locomotives). The *CFF Bulletin* mentioned in note (426) illustrates the main outlines of the present revised programme. We will confine ourselves to showing in figure 632 the first of four diesel-electric C'_0-C'_0 type locomotives, class Bm6/6, Nos. 1501/1504, put into service in December, 1954. These are long locomotives, 17 m overall, weighing 105 tons in working order, with a total horse power of 1 700. The electric traction motors are nose-suspended. The maximum speed in service is limited to 75 km (46 miles)/h as it was decided to have the greatest possible tractive effort. The machines can haul, and even start on curved track, a train of 1 200 tons on a 12 $^0/_{00}$ gradient. The constructors are SLM for the mechanical part, SULZER for the diesel motors, BBC (Brown Boveri) and SAAS (Secheron) for the electrical equipment.

A railway which has not yet been mentioned in this work, and which has, during recent years greatly increased its diesel haulage in place of steam traction, is the Irish Transport Company, Córas Iompair Éireann, CIÉ (450). This increase is at present (1954/55) in course of development and is above all due to the initiative of the Chief Mechanical Engineer, Mr. O.V.S. Bulleid, one of the best-known of locomotive engineers (previously of the LNER and Southern Railways, in England).

We can mention here only some general publications (451) but we shall return to the subject in the Supplement to *Vol. III*, in which we shall also try to deal, as far as space allows, with interesting introductions in other countries, including those mentioned in note (426). We intend also to return to the diesel stock

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(449) *Congress Bulletin*, February, 1948.

(450) Éire has peat, but practically no good quality coal. The C.I.É. includes all main and secondary railway lines in the country, almost all road services, and municipal transport undertakings and steamer services between Dublin and Liverpool. The C.I.É. thus has a practical monopoly of transport and, with a few exceptions, builds its own locomotives and rolling stock at the Inchicore Works (Dublin).

(451) See *E.T.T.*, Nos. 10-12, 1951, « Transport in Ireland » (in English), 4 p., map of the system, and 7-9, 1954, « C.I.É. Buffet Cars », 5 p., 7 figs. (English and French), J.J. Johnston.

— See also *Diesel Railway Traction (Gazette)*, June, 1952, p. 127, December, 1953, p. 268, June, 1954, p. 138, September, 1954, p. 220, October, 1954, p. 242, December, 1954, pp. 273-276 (narrow gauge, West Clare Railway), also *Congress Bulletin*, August, 1953, 6 p., 5 figs., tables, J.J. Johnston

in various parts of Africa. With regard to North America, see note (452).

We now pass to Austria. We have already described various electric vehicles [see figs. 462 and 464 and table, pp. 302 303 (453)] and have mentioned (p. 71, with regard to the Brown Boveri spring mechanism for transmission of torque by Simmering-Graz-Pauker, SGP, of Simmering (Vienna) and Graz; the electrical equipment was supplied by ELIN and Brown Boveri (Austria). Figure 633 shows one of the machines in service, figure 634 the dimensions and general arrangement and figure 635 the recoil arrangement for the two bogies.

Block *Bulletin des CFF*

Fig. 632. — Diesel-electric locomotive, C'_0-C'_0 type, class Bm 6/6, No. 1 501, of the Swiss CFF, hauling a freight train.

from electric motors to axles) the 22 diesel electric locomotives of the Austrian Federal Railways « Oesterreichische Bundesbahnen » BBÖ. These are class 2 045, type B'_0-B'_0, Nos 2 045.01-22, 730 (1 000) HP at 26 (31) km (16 [19] miles)/h, maximum speed 90 (95) km (55 [59] miles)/h, tare 66 tons (in working order 70 tons). The continuous tractive effort is 6.4 tons (maximum starting 15.8 tons). These machines are built, as regards mechanical parts and the two SGP-S12*a* diesel motors, each giving up to 500 HP,

We may further mention the 12 new diesel-hydraulic motor sets of the BBÖ, class VT.45 (50.45) reversible sets comprising one motored coach (of which the front bogie only is driving) and one trailer coach, with a total of four bogies, of which three are carrying. The driving coach is fitted with a Simmering diesel motor, 12 cylinders in V, and a VOITH-St. Pölten hydraulic transmission. The diesel motor gives 500 HP at 1 350 r.p.m. of which 460 HP serve for traction.

(452) For a general survey, see « Railroads of the U.S.A. », O.E.C.E., Paris, 1952. Diesel locomotives are dealt with on pp. 113-127.

(453) *Congress Bulletin*, May, 1953, and November, 1954.

The complete set weighs 70 tons in working order (84.6 tons loaded, 140 seats) and can run with a full load on a gradient of 25 $^0/_{00}$ at 45 km (28 miles)/h, maximum speed in service 115 km (71 miles)/h.

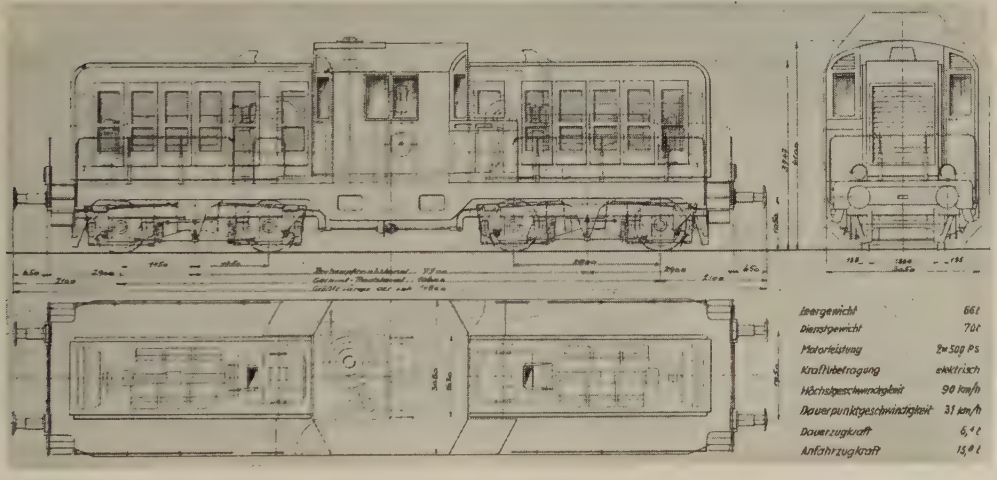
Photo BBC 80 304.

Fig. 633. — Diesel-electric locomotive, B′$_0$-B′$_0$, No. 2 045.03, of the Austrian Railways BBÖ, hauling a passenger train.

Figure 636 shows the first of these sets supplied by the SGP of Simmering. The main dimensions are as follows :

Overall length of the set . .	m	43.7
Width of body	»	2.94
Height of roof	»	3.96
(driving portion)		(4.4)
Bogie wheelbase :		
carrying	»	3.0
driving	»	4.1
Distance between bogie pivots	»	14.6
(motor coach)	»	(14.0)
Wheel diameter on tread . .		900 mm

Finally, still dealing with the BBÖ, twelve two-stage diesels, 26.8 m long, 4.54 m high, two bogies, of which one

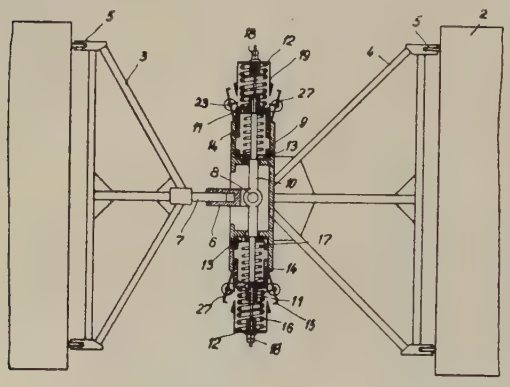


Plan SGP 40 358.

Fig. 634. — Elevation, front view and plan of class 2 045 locomotive (fig. 633) of the BBÖ (normal gauge).

Drehzapfenabstand = distance between bogie pivots.
Gesamtradstand = total wheelbase.
Grösste Länge der Lok = overall length.
Leergewicht = weight empty.
Dienstgewicht = weight in working order.
Motorleistung = H.P. of motors.
Kraftübertragung = transmission.
Höchstgeschwindigkeit = maximum speed in service.
Dauerpunktgeschw. = continuous power.
Dauerzugkraft = continuous tractive effort.
Anfahrzugkraft = starting tractive effort.

is driving, were put into service in 1950 (454). These also were supplied by Simmering (SGP) and have hydraulic transmission. Weight in working order 55 tons, power 500 HP, 110 seats. The cost was about 2 000 000 Austrian schillings (1949).



Plan SGP.

Fig. 635. — Recoil arrangement, shown in the centre of the elevation (fig. 634). For designation of parts, see Austrian patent No. 166757.

We now pass to South America. Mention was made at the end of Chapter VII (Rack railways) (455) of a case of diesel traction on a rack railway, with individual axle drive. Figure 637 shows the driving bogie of the diesel mechanical railcars of the Trans-Andine railway, « Ferrocarril Transandino » of Chile. The maximum gradient on the Chilean side (456) is only 80 $^0/_{00}$ and these cars run by adhesion on an Abt triple rack line, the corresponding triple gear wheel on the bogies serving only as an emergency brake. In the Supplement we shall return to these one-metre gauge railcars by the SCHINDLER WAGGON Co., already mentioned on several occasions, of Pratteln, near Bâle (Switzerland), and

Fig. 636. — Two car set (four bogies), series VT. 5 045.01, of the Austrian Federal Railways, BBÖ.

Photo SGP-992.

(454) See *E.T.T.*, Nos. 7-9, 1950 (special number for the International Railway Congress, Rome), « Stockwerkwagen in Oesterreich » (in German and French), 3 p., 3 figs., H. FEHLINGER.

(455) See Chapter VII, p. 701.

(456) The actual Transandine Railway is metre gauge, rack and adhesion combined, with maximum gradients of 61 $^0/_{00}$ (towards Argentine) and 80 $^0/_{00}$ (Chilian side); it goes from Mendoza (Argentine) to Los Andes (Chile) and connects at these two points with the wide gauge, 1.676 m to Buenos Aires and Santiago de Chile (total length : 1 442 km). The 43 km section from Rio Blanco to Las Cuevas (3 150 m high) was electrified about 1925, 3 000 V DC. See *Technische Blätter*, *SLM*, Winterthur, No. 5, 1928.

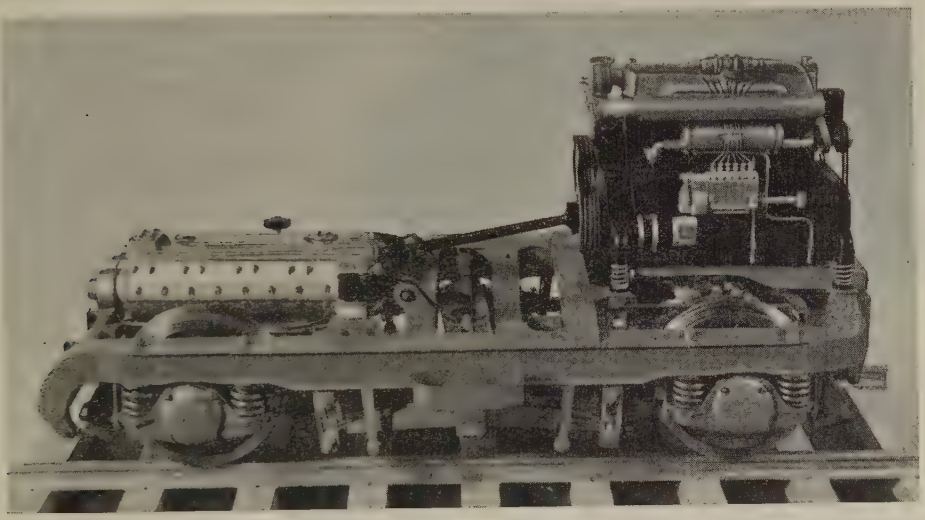
also to the one-metre gauge cars for adhesion working on the Chilean State Railways « Ferrocarriles del Estado de Chile », FF.CC.E.

The Vale of Rio Doce Railway, « Companhia Vale of Rio Doce, S.A. » of Rio de Janeiro, Brazil, put into service in 1954, a prototype diesel-hydraulic locomotive of 1 900 H.P., built by the KRUPP locomotive Works of Essen (Ruhr) for narrow gauge lines, speed 60 km (37 miles)/h in either direction, which is a noteworthy locomotive. The machine, No. 551 (fig. 638), is B'_0-B'_0-B'_0 type, in the sense that there are 3 driving bogies with 2 axles (or 6 driving axles); the body is articulated and the extreme parts (elongated bonnets) rest on the outer bogies; the inner parts of the two half-locomotives (one of which forms the single central driving cab) both rest on the central bogie.

The other main details are as follows :

Overall length	m	21.920
Maximum width	»	2.900
Maximum height	»	3.995
Total wheelbase	»	16.4
Bogie wheelbase	»	2.4
Tare weight	t	88
Weight in working order	t	96
Maximum tractive effort in starting (at wheel rim), approximatively	kg	32 000

The four-stroke diesel motors are of the MAN, W8V22/30 type, each develop-



SWP-958 (Photo Spreng).

Fig. 637. — Driving bogie of motor coaches of the Transandine Railways, FF.CC.E., Chile. On the centre of the right-hand axle can be seen (under the motor) the triple rack wheel, used only for braking (maximum gradient 80 $^0/_{00}$) when running by adhesion.

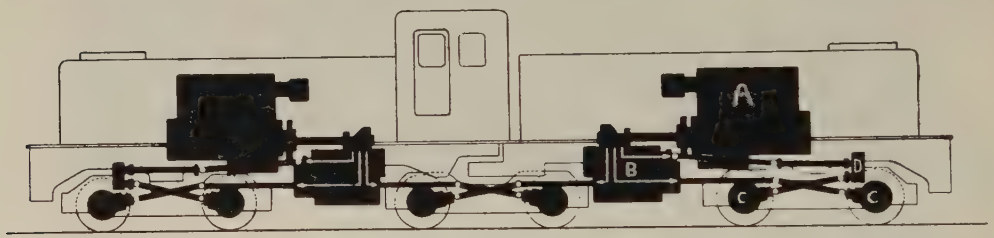
N. B. — This photograph is of a 1/5 scale model of the bogies of the cars under construction in 1954/55.

ing 1 000 HP at 960 r.p.m. Figure 639 shows diagrammatically the arrangement of the motors and transmission; other details can be obtained from the technical publications (457).

To conclude this Chapter, we can say that one should usually make use of the true individual axle drive, which has great advantages in traction. The « Fell » machine, of the British Railways, describ-

Fig. 638. — Prototype diesel-hydraulic locomotive, $B'_0B'_0B'_0$ type, articulated, with six driving axles, No. 551, of the Vale Rio Doce Company, Brazil, 1 m gauge, 2 000 HP, 96 t, 60 km/h built by Krupp (see fig. 639).

Block *Glasers Annalen.*



Plan Krupp.

Fig. 639. — Diagram of motor groups and drive of locomotive in figure 638; the cardan shafts are symmetrical in relation to the bogie pivots.

A = Diesel motor.

B = Transmission mounted in the main frame of each half locomotive, comprising :

3 hydraulic transmissions in parallel for each of the 3 driving axles of a half locomotive;
3 sets of mechanical transmission shafts; leading independently to each of the driving axles and each comprising two speed ranges and reverser.

C = Axle drive (conical gears).

D = Intermediate gears fitted to main frame.

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(457) See *Glasers Annalen*, Berlin, June, 1954, « 2 000-PS-dieselhydraulische Lokomotive mit Einzelachsantrieb », 1 p., 1 fig.

— *Diesel Railway Traction (Gazette)*, September, 1954, « 2 000 H.P. locomotive for Brazil », 214 p., 1 fig.

— *VDI-Nachrichten*, No. 7, 1954, p. 2.

— *The Engineer*, April, 1954, p. 543.

— *The Oil Engine and Gas Turbine*, July, 1954, p. 64

— *Die Loktechnik*, No. 7, 1954, etc.

ed earlier, has four diesel motors and four driving axles but the total power is passed by the central transmission. The solution for individual axle drive (which is relatively simple with electrical transmission) should, in our opinion, be sought in future preferably by individual hydraulic transmissions. We mentioned an example of this at the end of *Vol. II* (p. 309) but the Hydro-Titan system has not so far been used except for industrial tractors and public works undertakings.

For diesel-electric locomotives, the most simple traction motor is the nose-suspended type, but it has the drawback of greatly increasing the unsprung weight of the axles. This can be remedied, and a solution which in our opinion should be more widely considered, in view of experience so far, is to use resilient, rubber-mounted, wheels [see *Vol. II* (458) and Chapter II (459) in this series, *Vol. III*].

With mechanical transmission, the problem is more difficult, because it is necessary to have a diesel motor for each axle. Nevertheless, diesel-mechanical traction is the simplest for self-propelled vehicles, but it can be used only in cases which lend themselves to this form of traction.

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(458) Figs. 238*a*, 251, 255, 319, 341, 370, 376, 378 (*Congress Bulletin*, November, 1948, November 1949, and January, 1950).

(459) *Congress Bulletin*, January, 1953, figs. 403-414.

[625 .26 (73)]

Modern shop for heavy car repairs.

The Baltimore and Ohio stepped up freight car repairs about 50 percent by moving work indoors at Du Bois.

By Charles W. Behrens.

(*Modern Railroads*, June 1955).

In less than two years the Baltimore and Ohio Railroad has converted an abandoned steam locomotive back shop at Du Bois, Pa. into its largest and most modern freight car repair shop. Designed primarily for making heavy repairs on 20 freight cars per day, the huge indoor shop may also be used for reconditioning as well as the construction of new freight cars.

In fact, since the Du Bois shop was placed in operation less than a year ago, 500 new 50-ton box cars and 200 new 70-ton flat cars have rolled off its assembly lines.

Before conversion of the Du Bois shop was completed last June, all freight car repairs at Du Bois were made at the B & O's Brady Street car shop. Only a portion of the Brady Street shop is under cover and, therefore, during inclement weather outdoor production was somewhat curtailed.

Stripped cars are first brought to underframe shop where repairs on underframe and trucks are made. Shop accommodates 31 freight cars.

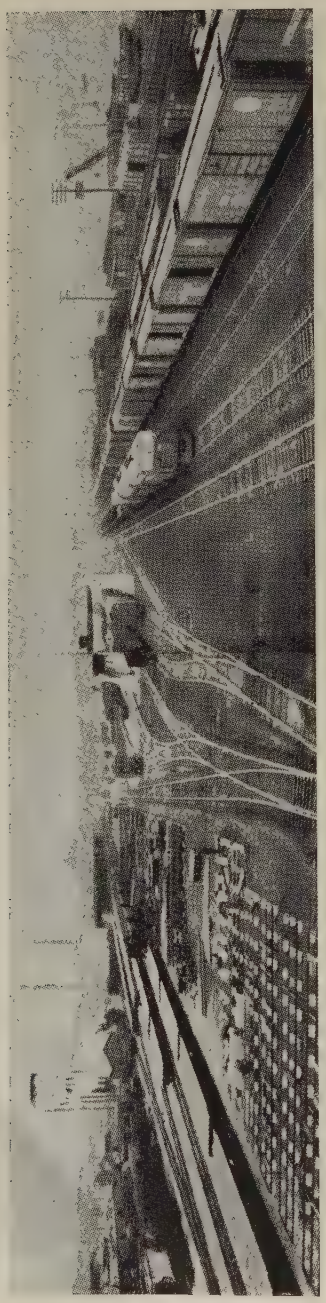
The converted back shop provides protection against varying weather conditions and the shop forces can now be kept working full strength at all times. The additional space, modern equipment and tools available in the new converted shop could efficiently accommodate a full-time crew of more than 600 men.

The three brick buildings, roundhouse

and yards which made up the steam locomotive back shop facilities, provided an excellent layout for the car shop. Much of the existing equipment, such as overhead cranes, building tracks, transfer tables, outdoor overhead cranes and shop power plant, were also used to advantage in the car shop.

After men have installed flooring, car will move on through to the adjoining paint shop.

Repairs on superstructure are made in 40-car capacity erection shop. New equipment, like these flat cars, is also built at the Du Bois shop.



Panoramic view of facilities at Du Bois. At left is paint shop and storage area, dismantling tracks, center, inbound bad-order car yard at right, and repair shops in background.

All inbound bad-order cars are placed in the 17-track yard adjacent to the shop buildings. A 1 000-HP Diesel switcher is used at Du Bois for shop switching in addition to the regularly assigned commercial switching at this station. This is done after an inspector has carefully checked over each car, made a report of the repairs necessary, and classified the work required as either light, recondition, or heavy repairs.

On the B & O, a light repair is one requiring from 1 to 20 man-h. Recondition repairs are classified as « B », 20 to 40 h; « B-1 », 40 to 60 h; and « B-2 », 60 to 80 h. Heavy repairs are designated as either « B-3 », 80 to 100 h, and « B-4 », over 100 h work. No light repairs are made at this Du Bois shop. As the shop is gradually organized on a more straight production line basis, only heavy repairs and new car construction will be handled at the shops.

After the bad-order cars have been inspected and classified, they are moved over to the dismantling tracks. All defective parts are then removed from the superstructure of the cars. Power tools and cutting torches, plus a system of overhead cranes and scaffolds, facilitate the work for the men.

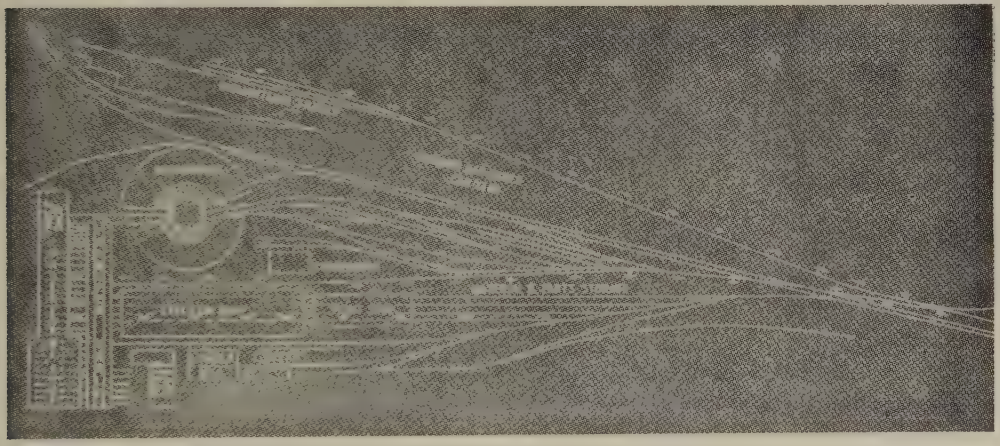
The stripped cars then move over to the underframe shop. The 148 × 623 ft locomotive boiler shop, with its 11 single-stall and 10 double-stall cross tracks, proved to be ideal for this shop. The double-hook overhead traveling crane, with capacities of 30 and 5 tons, in the center bay, and the 10-ton overhead cranes in each of the side bays, were « just right » for lifting freight car components. Large glass-block windows were installed along the outside walls. They with the system of mercury-arc and incandescent overhead lighting brighten the entire shop at all times.

The stripped car is then picked up by the overhead crane and set down on four steel supports. The trucks are then rolled out and transferred to the truck

repair shop which was set up at the south end of the shop. This modern truck shop contains four tracks with a capacity of 40 trucks. An ingenious system of Cleveland tram-rails, equipped with 12 3/4-ton and four 1 1/2-ton push-button pendant controlled electric hoists, serve the entire area. The tram-rail system is equipped with crossover tracks which make it possible to transfer any one, or all of the 16 hoists, to any portion of the area served.

blies may be stored. A shop-built dolly and air-operated wheel jack speed transfer of assemblies.

While the trucks are being rebuilt, the underframe of the car is being repaired or rebuilt in the other end of the shop. Up to 31 underframes, all accessible to overhead cranes, may be repaired simultaneously. Modern power tools and machinery, including air-operated rivet guns, electric arc welding units, acetylene-oxygen cutting torches, motor-driven



Layout and floor plans of the B & O's heavy repair shop at Du Bois. Cars move progressively through all shops along one continuous production line. Transfer table simplifies car movement.

A 42-inch Sellers wheel lathe and a Bickford journal lathe were installed. Both machines were completely redesigned and rebuilt from older lathes which had been in service at the B & O's Glenwood Diesel shop. (See *Modern Railroads*, April, 1955, p. 90.)

All axles are carefully inspected by a portable Magnaflux machine before and after the journals are trued. Defective truck castings and parts are reclaimed by building up any worn areas by arc welding and making the necessary repairs.

Adjacent to the truck repair shop is an outdoor storage track where defective and reconditioned wheel and axle assem-

punch presses and shears, simplify the work and improve the over-all efficiency.

The group of 16 Cheston electric rivet heaters which were distributed throughout the underframe and erection shops have speeded up many heavy repair operations. Each of the three types of rivet heaters being used, two, three and five electrode units, can be adjusted to the size and length of the rivet. The portable units will heat, in a matter of seconds, any rivet ranging in diameter from 1/2 to 1- inch, and up to five inches long.

Oxygen and acetylene for cutting torches and compressed air is piped into

all of the shop buildings. Service lines extend along the side walls and supporting columns. The acetylene and compressed air are produced on the premises; the oxygen is purchased.

When the repairs on the underframe of the car have been completed, it is raised up once more by the overhead crane and set down on its rebuilt trucks. The car is then transferred to the erection shop, the former steam locomotive back shop, where the repairs on the car superstructure are made.

Air brake cylinders are completely rebuilt. A shop-built bench and jig speeds reassembly.

Worn truck castings and parts are reclaimed by building up any worn areas by arc welding.

Movement of cars in and out of the underframe shop and across to the erection shop is simplified by a 65-ft electrically-operated transfer table. Originally 45 ft long when used for steam locomotive repairs, this table was lengthened 20 ft to accommodate the longest freight car in service on the B & O.

All cars are moved onto the transfer table and in and out of the various shop buildings by means of electrically-operated winches. One end of a heavy rope is attached to the car. The opposite end is wound around the winch. The operator then pushes a button to start the winch and the rope revolves around the drum to pull the car down the tracks. By coupling cars together, as many as four cars may be moved simultaneously as a train.

The 134 × 524-ft erection shop has four through-tracks which can accommodate up to 40 freight cars of various types. Three of these tracks are served by two double-hook overhead traveling cranes; the large hook has a 65-ton capacity, and the small hook a capacity of six tons. The other track is served by a five-ton Cleveland overhead tram-rail with electric hoist. Modern Balfour rolling steel doors were installed in the end walls over each of the four tracks.

All repairs on the car superstructure are completed in the erection shop, including the rebuilding and application of safety appliances. Repair work on the cars is made progressively as the cars move on through the shop.

Air brake cylinders are overhauled on a bench mounted against one of the outside walls of the erection shop. The mechanic first dismantles each cylinder and cleans all of the component parts. After checking each part carefully, the

cylinder is reassembled with the help of a special shop-built jig.

Bent steel angles, used to reinforce the tops of open-car sides, are straightened on a machine which was designed and built in the shop. The simple device consists of a hydraulic press and a roller conveyor system. The long steel angles are carried over to the machine by a mobile crane. The bent angle is then fed into the straightening press along a roller conveyor. A similar conveyor carries the angle on through the press and beyond it until the entire angle has been straightened.

Lumber required for repairs on freight cars is prepared in a carpenter shop conveniently located along one side of the erection shop. It was converted from the old locomotive blacksmith shop and handles all types of lumber and mill work. Roller conveyors were installed below both high-speed saws to simplify lumber cutting operations.

As the cars are completed, they are moved on through the erection shop directly into a 94 × 280 ft paint shop. This is the only building that had to be constructed during the conversion. It has four through tracks connecting with those in the erection shop. These same tracks extend on through the paint shop, providing a secondary outdoor painting area. The four tracks have a total capacity of approximately 100 cars, 20 of which may be housed in the new building.

All trucks are stripped and rebuilt. The shop has four tracks with capacity of 40 trucks. Entire shop is served by system of bridge transfer cranes equipped with overhead hoists.

The scaffolding system which parallels all of the tracks simplifies spraying the roofs and upper portions of the cars. Compressed air lines are mounted along the rails, with outlet valves at intervals, for the spray guns. Fifty-six exhaust fans are mounted in the roof of the shop to remove any harmful paint fumes. The lower portion of the entire building is open to the air.

Adjacent to the paint shop is a large outdoor storage yard for heavy car components. A 25-ton Industrial Brownhoist Diesel-powered crane, and four steam-

powered cranes, one 20-ton and three 15-ton, are used to transport material and parts. A well-stocked and neatly-kept two-story storehouse faces this storage yard. All of the many smaller parts, pre-fabricated freight car parts and miscellaneous items are issued from here.

« Nerve-center » of the entire shop facilities is a modern power plant which faces the erection and carpenter shops. Two new 600-HP Amsteam boilers supply the steam needed for heating all of the various shop buildings. The completely-automatic packaged-units are designed for operation on either natural gas or oil. Two new Chicago Pneumatic 1 345 cfm electric air compressors, a D.C. generator, modern control panel,

Modern tools and equipment, like the electric rivet heater at right, have done much to simplify and speed up repair operations at Du Bois.

Bent reinforcement angles are straightened in shop-built machine. The long angles are guided in and out of the press along roller-conveyor.

and other equipment are also housed in this building.

All apprentice workmen at the Du Bois shop, and all B & O shops, are required to take a special home-study training course. Supplied free by the B & O, the lessons include basic mathematics, reading blueprints, drawing technical sketches, and AAR interchange and loading rules.

The B & O began to realize the benecits of the Du Bois conversion and modernization program soon after the new shops were placed in operation. Repairs on freight cars and a new car construction have been stepped up more than 50 % over that accomplished when most of the men were working outdoors. The overall efficiency of the entire operation has increased a corresponding amount.

The shop was planned for straight line production. At regular intervals the cars are moved progressively from position to position along one continuous line extending through all the shops. At each position a crew completes a predetermined phase of the repair work until the cars roll out painted and stencilled, like new. The Baltimore and Ohio has already demonstrated the merits of such a production line set-up at its Keyser, W. V. car shop.

[656 .212 .5 (73)]

Electronic equipment in U.S.A. marshalling yard.

Radar operated speed indicator and automatic calculator.

(*The Railway Gazette*, May 20, 1955).

An experiment in the automatic retardation of freight cars in a hump marshalling yard has recently been installed on the Union Pacific Railroad at North Platte, Nebraska, on the main line between Omaha and Cheyenne.

The Electronic Yardmaster consists of two devices; a radar-operated speed indicator and an electronic calculator. The speed indicator, located near the foot of the hump and in advance of the points and retarder, measures the speed of a descending car and the distance it must travel, and transmits the information to the electronic calculator in the control tower, which operates the electro-pneumatic retarder. The amount of braking force applied by the retarder is automatically

Electronic yardmaster control equipment.

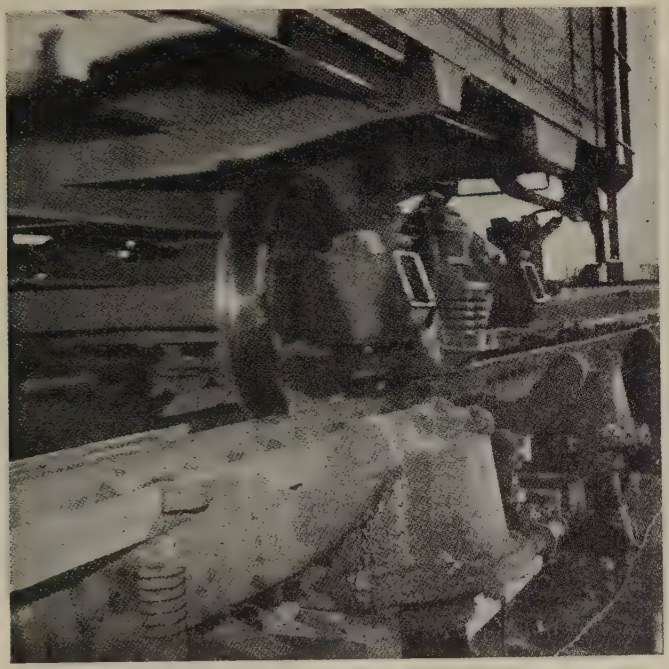
Known as the Electronic Yardmaster, the equipment has been applied experimentally to eight tracks, but is to be extended to the remaining 34 tracks in the yard, in which up to 4 000 freight cars are handled every 24 hr.

adjusted to the information relayed from the speedmeter in such a manner that cars roll through the points and couple with preceding cars, already standing on the tracks, at about 3 m.p.h. The calculator also records and calculates the shortened distance each car must travel as each track under its control becomes progressively filled, causing the force applied by the retarder to be adjusted accordingly. Up to 120 cars can thus be « remembered ».

Anticipation of shunting sequence.

The destinations of the cars in each train are teletyped in advance to the yardmaster, who relays the information to the control tower operator, who works out the shunting sequence. Thereafter the tracks are selected and points operated by push button control.

The design and experimental work on this equipment was developed jointly by the railway company and the Reeves Instrument Corporation.



Electro-pneumatic retarder installation.

[625 .143 .3 (73)]

New rail-grinder train... takes off the rough spots.

(*Railway Track and Structures*, June 1955.)

The train comprises eight specially-designed grinder cars and a power car. Four of grinder cars are equipped with control cabs, while others are remotely controlled from cab on adjacent car. Locomotive moves train along at about 2 m.p.h.

Frank Speno Railroad Ballast Cleaning Company builds all-new nine-car train designed to grind the running surface of rail, out of face. As train moves along at about 2 m.p.h., 96 power-driven abrasive wheels, mounted on special truck assemblies beneath cars, grind out corrugations and other surface irregularities on both rails simultaneously. Built at a cost of around $ 500 000, the train is owned and operated by Speno and is being made available to railroads on a contractual basis.

« What is that thing? » queried one bystander. « Darned if I know! » replied a fellow sidewalk super-intendent as they watched a train of nine odd-looking cars, caboose and engine round a curve amid a shower of sparks and flying dust. As the dust cleared with the passing of the last whirring car, the shiny, polished surface of the rail revealed the answer. The « thing » was a rail-grinding train.

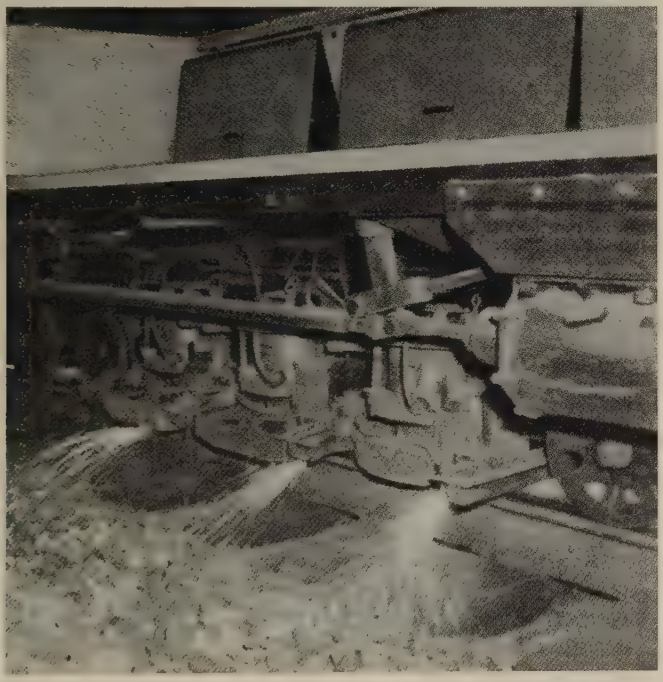
Designed for out-of-face use in removing corrugations and other minor imperfections of the running surface of rail, the train was built and is operated by the Frank Speno Railroad Ballast Cleaning Company, Ithaca, N. Y., a firm well-know for its work in the ballast-cleaning field.

The train is composed of eight specially-built grinder cars and an EMD power car. The grinder cars are an adaptation of similar cars developed by the Pennsylvania, which have been in regular use on that road for a number of years.

The successful operation of the PRR rail grinder cars, and the apparent need for additional equipment of this type, indicated to the Speno Company that there was a market for commercial development of similar equipment. It was apparent that the expense of building a complete grinder train was the principal deterrent to more widespread use of rail-grinding practice. Frank Speno, Jr., president of the Frank Speno Company, felt that the development of such a train by his company for rental to the railroads offered a logical solution to the problem.

Lackawanna uses it first.

The new train went into service early in March on the Lackawanna and has, since that time, been used on the Lehigh Valley. Other roads are presently contemplating its use on their lines. When our reporter visited the train on the Lackawanna in late March, it was completing out-of-face grinding operations on about 350 miles of main-line track. This mileage had been completed in only 24 days of operation, or an average of about 14 ½ miles per day.

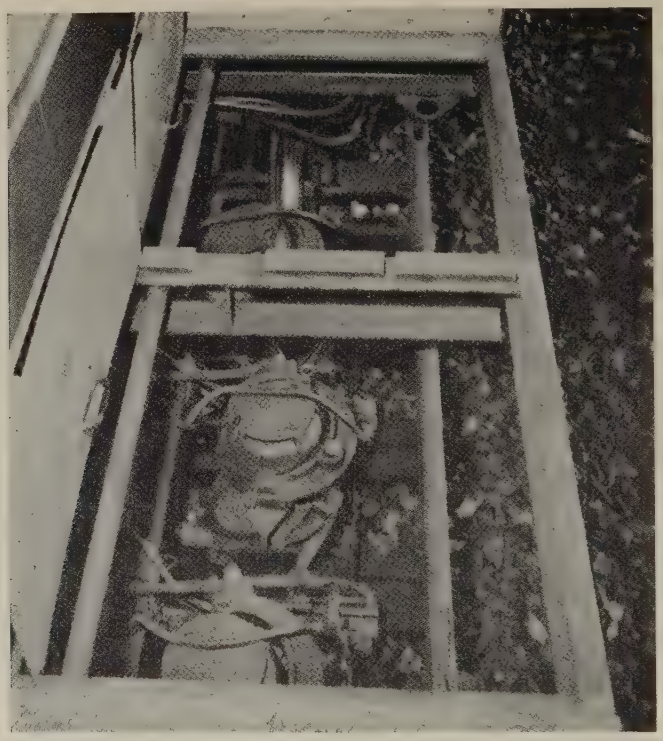


How grinding is done... Abrasive wheels, powered by 7 ½-HP electric motors mounted on special « pony » trucks under cars, grind rail surface.

Most of the grinding on the Lacka-

wanna was done on the road's multiple-track Hoboken-Buffalo line where traffic density is extremely heavy. The train was kept on duty for an average of about 11 h each day; however, due to the heavy traffic, it was able to spend only about 7 h per day actually working. The remainder of the time was consumed in going to and from tie-up points and in clearing trains which could not be detoured. The cost of grinding, including rental of the equipment, personnel for operating the cars and the work train to handle the equipment, has been running less than $ 100 per mile of track.

The practice of rail grinding out-of-face is not new to the Lackawanna since that road has used the Pennsylvania grinder cars during recent years. In the future the road intends to continue a program of rail grinding as necessity requires.

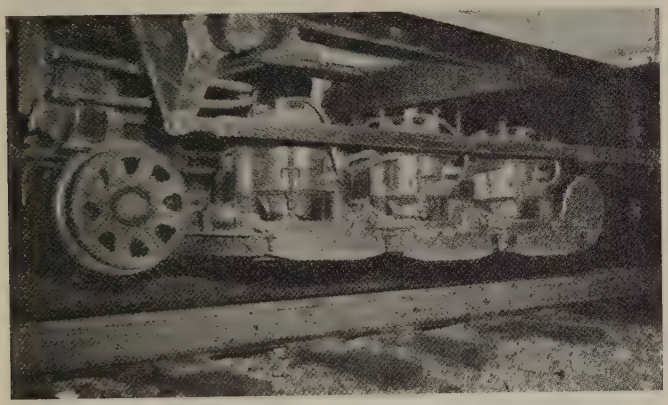


Motors are tipped at angles from vertical to provide various grinding planes and maintain contour of rail head.

New rail to be ground.

The Lackawanna plans not only to grind old rail but to grind newly laid rail as well. The purpose in grinding the new rail, according to engineering officers, would be to reduce variations in rail height at joints due to extremes of mill tolerance and to remove mill scale and other minor irregularities in the surface before they have a chance to develop to a more serious degree.

Some of the advantages claimed for rail grinding are: elimination of irregularities which cause vibration in locomotives and rolling stock and increase the maintenance of such equipment; a smoother ride for passenger trains; reduced rail and joint maintenance; and reduced track maintenance effected by the reduction of vibration. Furthermore, Mr. Speno foresees, through the employment of a cycled program of rail grinding, the possibility of adding considerably to the service life of rail. His reasoning is that, if surface imperfections can be eliminated, or at least held in check so that their development is not so rapid, the life of rail would be extended indefinitely, the actual wear on the head then being the only critical factor.



« Pony » trucks are raised from rail by pneumatic cylinders when not in use. Special locking devices hold trucks in place.

Cars built in Speno's plant.

The eight specially-designed grinder cars were assembled in Speno's plant at Syracuse, N. Y. The car underframes and trucks were furnished by the International Steel Company, Evansville, Ind. Each of the cars is fitted with two specially-built « pony » trucks furnished by Fairmont Railway Motors, Inc. These « pony » trucks are suspended from the underframe of the cars and are used to support the grinder motors. There are six Reliance, 7 ½-HP, 3 600 r.p.m., 440 V motors mounted on each truck, three over each rail. The motors are arranged in a straight line over the rail but can be tipped at angles so as to provide various grinding planes on the rail-head surface. Each motor powers a 10-in by 1 ¾-in steel-back grinding wheel.

The « pony » trucks can be raised and lowered from the rails by means of pneumatic cylinders. When not in operation, the trucks are raised and locked into position by pins and toggle levers. The grinder motors are each mounted in a cradle on the trucks and can move up or down in this cradle to give the desired pressure of the stone against the rail surface. This pressure is maintained at a constant level by means of two hydraulic-pneumatic cylinders, one on each side of the motor. Each motor weighs about 300 lb., and if the motors were to bear with the full force of their weight on the rail, the pressure would

be too great; therefore, the cylinders on each side of the motor push upward so as to carry a portion of the motor weight and obtain the correct pressure of the stone against the rail.

During operation, the pneumatic and hydraulic controls for both the « pony » trucks and the grinder motors are handled by four operators. Every other one of the eight grinder cars is fitted with a cab at one end of the car. A control panel in each of these cabs provides pneumatic and hydraulic controls for raising and lowering the trucks and motors, and electrical-circuit controls. Each operator regulates the grinder assemblies on a cab-equipped grinder car as well as on the « idler » car immediately ahead, which has no cab.

Each of the control panels has 24 ammeters and a like number of air-pressure gages, one each for all the grinder motors operated from that panel. By watching the ammeters, the operator can determine whether each grinding stone is bearing with the correct pressure against the rail surface. It has been determined that, when the motor is drawing about 6.9 amp of current, the grinding is most effective. By adjusting the pneumatic-hydraulic pressure in the cylinders supporting each motor, the operator is able to maintain the desired 6.9 amp of current to each motor.

Operation of train... Paging system permits relaying instructions and warnings of approaching trains and obstructions to train personnel.

If the ammeter reading on a particular motor should go up to say 7.5 amp, then the operator opens the air valve to the cylinders on that motor, thereby raising the unit slightly, reducing the pressure of the grinder wheel against the rail and lowering the current consumption of the motor. If the reading should become too low, then the pressure on the cylinder supporting the motor is reduced, thus increasing the bearing of the wheel against the rail and increasing the current load of the motor.

The air-pressure gages on the control board also serve as a means of indicating whether the grinder wheel is operating

Train crew also maintains communication with engine and grinder-car operators through portable talk-back speaker.

Engineer has special speedometer to aid holding 2-m.p.h. speed.

at the desired pressure against the rail surface. It has been found that when an air pressure of about 20 psi shows on the gage, the stone is bearing at the proper pressure.

How head contour is maintained.

To obtain the desired head radius when grinding, the six grinder motors over each rail on each car are set at different angles with reference to the vertical plane of the rail. The motor grinding nearest the gage side of the rail is tilted at the greatest angle from vertical and the motor grinding at the point nearest to the center of the rail head is in a vertical position. The other four motors are tilted at angles between these two extremes. Hand cranks are provided on each grinding unit to adjust them to the desired angle. With this arrangement on each car, and with a total of eight cars, it can be seen that there are a total of eight motors on each rail throughout the train which are grinding in the same plane.

The total metal removed from the rail surface as the train passes is somewhere between 0.008 and 0.10 in. Two general types of grinding stones are used, one with coarse grit for removing metal rapidly, and the other with a fine grit for finishing. To permit the train to be operated in either direction, the coarse-grit stones are located on the center grinding cars while the cars on each end are fitted with the finer finishing stones.

Power, control system... Power car, placed at one end of train, furnishes electricity and air for operation of grinder cars.

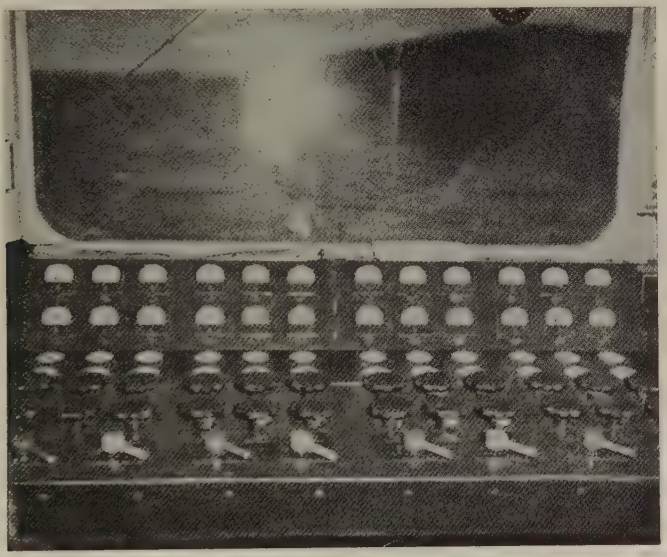
The train is moved along at about 2 m.p.h. which has been found through past experience to be the most effective speed. At higher speeds insufficient metal is removed to eliminate imperfections in the rail surface, and at lower speeds too much metal is removed. The hydraulic and pneumatic control mechanisms are all set up so that, if the speed of the train falls below 0.9 m.p.h. the grinder wheels are automatically lifted from the rail. This is a safety precaution to prevent the stones from actually grinding a hole in the rail head in case the train is stopped without warning. To permit the locomotive engineer to maintain the

desired 2-m.p.h. speed, a special portable speedometer, calibrated from 0 to 5 m.p.h. is installed in the locomotive cab. The speedometer is activated by a tachometer generator attached to a « pony » truck of the grinder car nearest the engine.

Additional men for lookouts.

In addition to the four operators stationed in the control cabs two operators are on duty on the ground at all times. These men walk along the train looking for any mechanical troubles and keep an eye out for road crossings, switches, rail lubricators, etc., and give signals for raising and lowering the grinder motors when passing over these obstructions. These men also « lock up » the grinder assemblies when grinding operations are to be suspended for any reason. The railroad furnishes one man, in addition to the train crew, for supervision of the grinding operations. All other personnel are furnished by the Speno Company.

Electrical power for operating the grinder motors, as well as compressed air for operation of the various pneumatic mechanisms, is furnished by the EMD power car. This car, which looks very much like a « B » road-locomotive unit, contains a 12-cylinder Diesel engine which powers a 440-V, 750-kVA main generator, a 440-V, 25-kVA auxiliary generator and a Gardner-Denver air compressor. One section of the car is devoted entirely to electrical control panels.



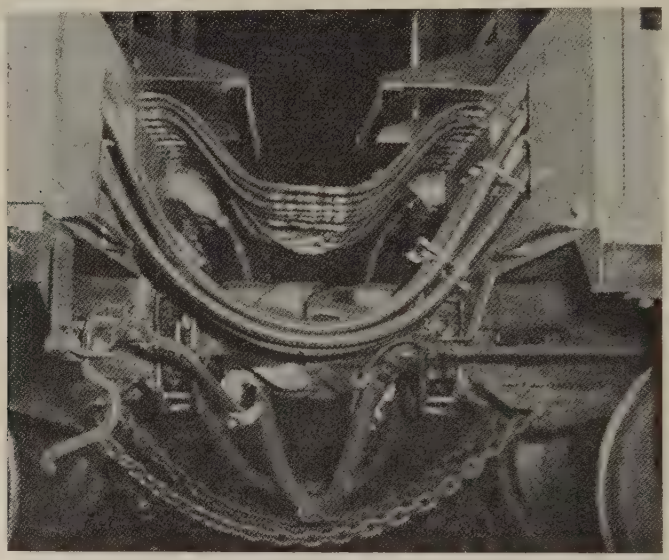
Control panels in cab-equipped cars have valves and gages for use in operating grinder assemblies.

The power car is situated at one end of the string of grinder cars and electrical power cables and compressed air lines extend through the entire train. Connections between cars are provided by flexible cables and hoses. Electricity and air from the main lines extending to the power car are supplied directly to the control cabs on each of the four control cars, then distributed to the grinder

assemblies on the cab cars and to the remotely-controlled « idler » cars ahead. Electrical and pneumatic connections between the cab cars and their respective « idler » cars are also provided by flexible cables and hoses.

The entire train, including the engine and caboose, is equipped with a paging-speaker system with microphones and speakers mounted inside each control cab, and speakers on the outside wall of each cab. The caboose and engine are each supplied with a portable talk-back speaker unit. Instructions to the various grinder-car operators and train and engine crews and warnings of approaching trains, obstructions and the like are relayed over the speaker system. For night operations adjustable floodlights are mounted on both ends of each cab.

The operator cabs have large windows, double glazed with Duplate safety glass, on all sides. The extensive use of glass in the cabs permits the operators to observe operations all along and on both sides of the train. The cabs are fully insulated throughout and each is equipped with a Fedders air-conditioning unit and a Chromalox electrical heater. Lighting on the inside of each cab is furnished by an overhead incandescent fixture and, to eliminate glare at night, a desk-type fluorescent fixture above each control board. Each cab also has a steel work bench with a vise and shelves to use for general repair work and the storage of spare parts.



Flexible hoses, cables transmit air, electricity between cars.

[625 .142 (44) & 625 .18 (44)]

The policy of the S.N.C.F. as regards sleeper supplies,

by R. Lévi,

Directeur des Installations Fixes de la Société Nationale des Chemins de fer français.

(*Revue Générale des Chemins de fer*, November 1954.)

At the present time some 120 million sleepers are in use on the S. N. C. F., 6 million of which are metal sleepers and 2 million reinforced concrete.

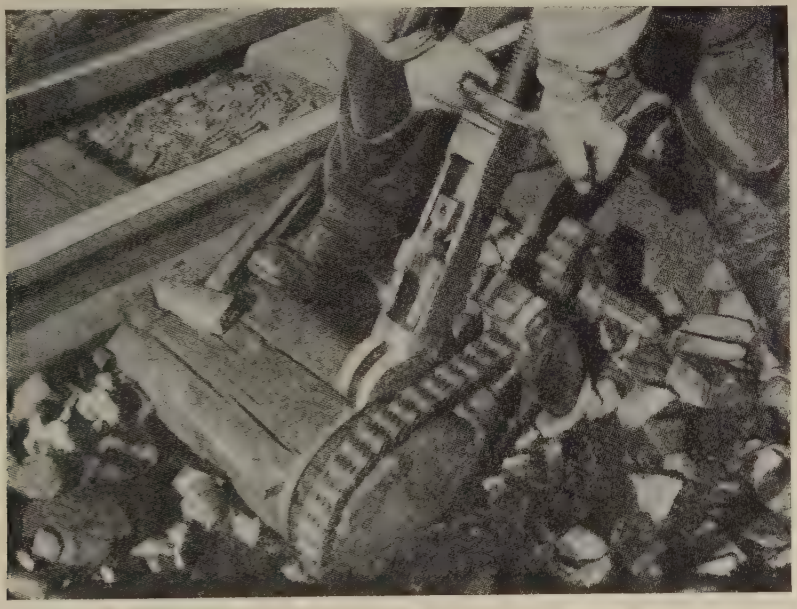


Fig. 1. — Binding a split sleeper on the track, by the Delor process.

At the present time, new sleepers are systematically bound in the shops, up to more than one third of those supplied, so as to reduce the cost of this operation and prevent cracks that are begining from growing.

When main lines are renewed, both the rails and sleepers are dealt with if possible. In this way, it is possible to make the best use of the high standard of work and excellent output of the mechanised gangs, and reduce to the minimum any loosening of the track which impairs its quality. In the intervals between general overhauls, maintenance gangs are used to prolong as much as possible the life of the sleepers by various operations, such as: binding (1)

(1) See *Revue Générale des Chemins de fer*, November-December 1941, p. 347, article by M. Delor.

the ends of wood sleepers to prevent cracks loosening the wood round the thread of the coachscrews (fig. 1), restoring the part of the sleeper on which the rails rest, recutting the shoulders (fig. 2), adding packing pieces to holes in which the coachscrews no longer engage, drilling new holes (fig. 3), as well as replacing

meet its requirements, this would no doubt have followed a regular rhythm. But the upsets caused by the wars both as regards keeping up stores and carrying out the programme set have led to considerable fluctuations of about 5 000 000 a year.

For a long time the French Railways

Fig. 2. — Overhauling the fastenings on the classical type of track with ordinary coachscrews.

The foreman (first on the left) marks the sleepers to be recut. The two following platelayers (to the right) unscrew the marked coachscrews which are loose in the wood and no longer bear upon the rail. The next two recut the shoulders, one with a chisel, the other with an adze. The next man paints the newly cut wood to protect it against rot. The last two, on the right, tighten up the coachscrews.

single sleepers which have worn prematurely. On secondary lines, it will be found necessary to replace a greater number of single sleepers than on the main lines, as the rails on such lines last longer.

The sleeper requirements can therefore be divided into two parts, which are in fact equal, corresponding to the continuous main overhaul work and the scattered maintenance work.

If the S. N. C. F. had always been able to obtain sleepers without difficulty to

have carried out trials with two substitutes for wood sleepers : metal and reinforced concrete.

In these trials the rails were supported directly on the sleepers, according to the current French practice, where the use of metal bearing plates is avoided as far as possible, as this considerably increases the cost of the permanent way.

Under these conditions, metal sleepers which give good results on lines with relatively little traffic, give poor results

with heavy loads or high speeds. If this is to be overcome, much heavier sleepers will have to be used, or else they will have to be fitted with bearing plates, which will make them much more expensive than wood sleepers. On the other hand, the metal sleeper, which again cannot be used on lines with track that metal sleepers offer considerable resistance to transverse stresses, so that the gauge of the track remains very constant. They have therefore considerable technical advantages on lines with many small radius curves, where such transverse stresses are considerable and the speeds moderate.

Fig. 3. — Tightening up the fastenings.

This is the second operation which completes the overhaul of the fastenings. The loose coachscrews after tightening up are marked. The foreman decides what is to be done : drilling another hole and stopping up the old hole or stopping up the old hole and drilling out the plug. The two platelayers on the right are doing the final tightening up.

Other methods can be used in certain cases : putting in packings to strengthen the grip of the coachscrews, using metal sheaths or eyelets, etc.

Such repairs require skilled labour. Unfortunately the effects are very short lived.

circuits, does not give the same quality of layout, which is another obstacle to its use on high speed lines.

On the other hand, it has been recognised that wherever the strength of metal sleepers is not affected by the severity of the traffic, they are very little affected by the weather, so that the maintenance of the track as a whole is very much reduced. In addition, it is indisputable

As regards reinforced concrete sleepers, in the past opinions have been very divided, and several railways have hesitated to use such sleepers extensively; in fact, they have given rise to much criticism as regards the fastenings and the joints in particular.

Finally, it must be recognised that the wooden sleeper cannot claim to have nothing but advantages; if it can be

agreed that its life is about 25 to 35 years, with a down grading round about the 20th year, it must also be recognised that long before this time a considerable proportion of the sleepers will no longer be in service (through rotting, splitting or being burnt).

It is however agreed from the above that the wooden sleepers is really the only one that is any good for important lines, and as a rule is more advantageous than its substitutes, owing to the great difference in price between them. However, on very twisting lines with curves of small radius, it would appear better to use metal sleepers.

The S. N. C. F. had therefore no legitimate reason for modifying the principles arising from the above remarks, but circumstances have obliged them to do so.

Since the last war, in fact, the timber market has undergone many profound changes which can have a dangerous effect upon the amount of sleepers manufactured. These are made either from relatively small trees or from the offcuts formerly available after industrial manufactures, which consequently were a by-product of the forestry industry; but new uses found for timber and technical progress means that there is now less waste; on the other hand, these two causes are contradicted as far as the total consumption of the country is concerned.

Although at the present time it is difficult to pass any judgment on the regime that might be established under new circumstances, the above may explain the very great variations that occur in the wooden sleeper market. That part of the annual thinnings from the forest which were automatically used for sleepers, formerly of the order of 8 %, has irrevocably declined, and as regards the remainder, there is competition between the manufacturers of sleepers and other products. The volume of wooden sleepers offered is therefore largely influenced by the market in other sectors.

The fluctuations recorded during the last few years therefore give us some idea of what may occur in the future as a result of new uses being found for wood, in the chemical field for example, competing with other materials, especially metals in the construction and fabrication of furniture. To make the problem clear, we may say that the number of white wood sleepers delivered in 1951 was only half the number offered for the same year and one third of the number required for the present year.

The problem it twofold : it covers both the amount of sleepers delivered and their cost. The solution must also therefore be twofold; the regulating of both quantities and prices can only be obtained by using other substitute kinds of sleepers at the same time.

Luckily, technical progress has resulted in the perfecting of the prestressed concrete sleeper since the war, as well as combined sleepers which can be used as substitutes.

Prestressed concrete sleepers had already been used on the British Railways. The S. N. C. F. asked that great expert in prestressed concrete, M. Eugène FREYSSINET, to interest himself in the question, and then gave an order for the first formula for prestressed concrete sleepers. From this, 250 000 were manufactured between 1948 and 1951 which appear to be satisfactory on the whole but the technique of which has now been superseded.

The studies made by the Engineers of the S. N. C. F. then led to a model which was patented in the name of the S. N. C. F. and two Engineers (Messrs. VALETTE and WEINBERG) who designed it, the S. N. C. F.-V. W. sleepers. The first of these sleepers were laid in 1950, but it was only at the beginning of 1953 that they were laid on a large scale on a line of some importance : Bourges to Montluçon. It will be some time before it can be decided whether these sleepers can be used on lines with a greater number of trains.

As indicated in a previous number of the *Revue Générale* (1), the doubly elastic fastening was designed to avoid the impact blows which rolling loads might exert on the concrete.

On the other hand, the creation of these fastenings led to the idea of a sleeper the concrete parts of which are designed to carrying the fastenings so that the causes of defects in certain previous types are eliminated (fig. 4). The sleeper in question was patented in the name of the S. N. C. F. and the Engineer (Mr. Sonneville) who designed it; the R. S. sleeper of which there are now 1 150 000 in France.

There is also the Laval sleeper (longrine Laval), the first extensive use of which goes back about 5 years, which is still being improved. These are reinforced or prestressed concrete components arranged longitudinally under each rail, supporting it at several points (fig. 5). It would appear that this type of support may very shortly compete with the different types of sleepers.

* * *

As regards sleepers made of substitute materials for wood, the following technical conclusions have been arrived at:

1) as regards the R. S. sleeper, the cost of which including laying in the track is approximately the same at the present time as that of wood sleepers laid on main lines, but 15 to 20 % higher on other lines, this can already be compared from every point of view with wood sleepers. It may even be thought that this is the best sleeper to use on average lines (provided they are not fitted with track circuits) laid with long rails, as this is particularly suitable for heavy sleepers.

On the other hand, the robustness of this sleeper makes it possible to hope for an appreciable reduction in maintenance costs, which should facilitate the reorganisation of the maintenance as a whole, the only way in the future of making further savings in the maintenance of the track;

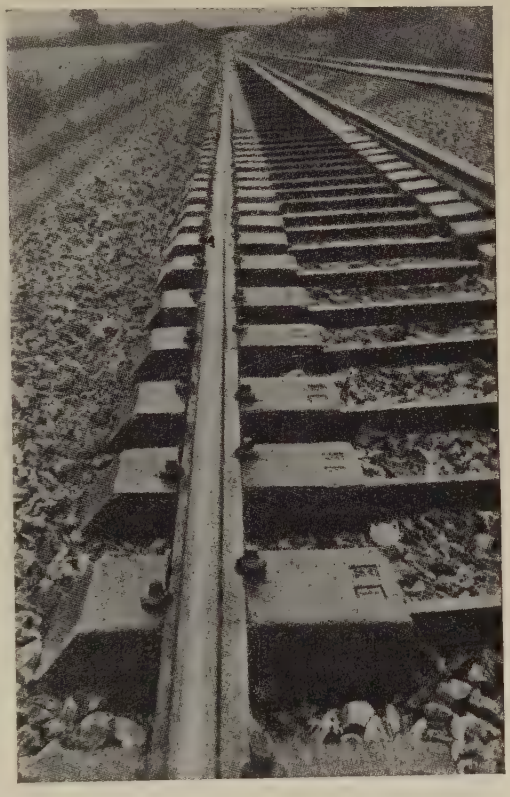


Fig. 4. — Old « Vagneux » type mixed sleepers on the Amiens-Rouen line.

In spite of the well known defects of fastenings by coachscrews, with wooden bearing plates between the rail and the concrete, the blocks of these sleepers are still standing up very well in spite of their age (date of manufacture : January 1930).

2) it is too early to decide if prestressed concrete sleepers can replace (from the technical point of view) wooden sleepers on main lines; it will require

(1) *Revue Générale des Chemins de fer*, November 1952 : Fastening the rails to the sleepers. Five years of experience of doubly elastic fastenings.

several years to come to a definite decision on this point. But it is already certain — a point we shall return to later on — that these sleepers are costly and their technical success alone will not enable them to compete with wood sleepers;

3) the metal sleper remains a necessity on lines with many curves used by heavy locomotives which exercise a marked transversal stress on the track.

Fig. 5. — Track laid on reinforced concrete « Laval » girders (longrines Laval).

The rails are kept at the correct gauge and cant by means of cross ties made of old bent D.C. rails. The rails are welded into long lengths and fixed to the concrete by double elastic type fastenings. (Paris-Soissons line, near Crépy-en-Valois). These girders are laid on gravel to facilitate levelling operations.

These qualitative considerations must be completed by economic comparisons. To make the relations between the different sleepers clear, we will begin by indicating below the total costs at the present time, obtained by adding the cost of buying the sleeper, including all manufacturing costs, transport, storing, bearing plates and the fastenings, as well as handling and laying.

A — Hard wood sleeper laid without bearing plates with ordinary fastenings .	2 820 fr. fr.
B — Hard wood sleeper laid with bearing plate and ordinary fastenings . . .	3 220 fr. fr.
C — Hard wood sleeper laid with elastic type fastenings (1/4 with bearing plates)	3 370 fr. fr.
D — R. S. sleeper with elastic type fastenings	3 830 fr. fr.
E — Metal sleeper without bearing plate	4 120 fr. fr.
F — Prestressed concrete sleeper with elastic type fastenings	5 100 fr. fr.

The comparison should be slightly revised in order to take into account certain supplementary factors; on the one hand, wooden sleepers are often liable to get burnt on lines run over by steam locomotives, which means an additional cost which can be taken as an average of 50 fr. fr. on the whole of the lines of the S. N. C. F.; on the other hand, with the same thickness of ballast under the sleeper, the R. S. sleepers, metal sleepers and prestressed concrete sleepers require respectively 0.110 m^3, 0.200 m^3 and 0.110 m^3 *less* ballast than wooden sleepers. The table of capital costs after making these adjustments becomes :

A — 2 870 fr. fr.
B — 3 270 fr. fr.
C — 3 420 fr. fr.
D — 3 720 fr. fr.
E — 3 920 fr. fr.
F — 4 990 fr. fr.

Account must also be taken of the longer or shorter period after which replacements will be required. The usual accountancy calculations show that if the rate of interest is 5 %, the capital needed to assure the renewal of a given amount

every 30 years is equal to 0.301 of this amount; for a period of 40 years, this fraction is reduced to 0.166.

For the sake of simplicity, we will take it that the value of the reusable material taken up will pay for the cost of taking it up, and consequently we will take the fractions 0.301 or 0.166 of the sums given above in order to ascertain the capital required for future renewals.

The annual capital costs for the different types of sleepers work out as follows :

A — Life 30 years : 5 % (1.301 × 2 870) = ... 186.7 fr. fr.
B — Life 30 years : 5 % (1.301 × 3 270) = ... 212.7 fr. fr.
C — Life 40 years : 5 % (1.166 × 3 720) = ... 216.8 fr. fr.
D — Life 30 years : 5 % (1.301 × 3 420) = ... 222.2 fr. fr.
E — Life 40 years : 5 % (1.166 × 3 920) = ... 228.6 fr. fr.
D — Life 30 years : 5 % (3 720 + 0.301 × 2 870) = . . . 229.2 fr. fr.
E — Life 30 years : 5 % (3 920 + 0.301 × 3 270) = . . . 245.2 fr. fr.
F — Life 40 years : 5 % (1.166 × 4 990) = ... 290.9 fr. fr.
F — Life 30 years : 5 % (4 990 + 0.31 × 3 270) = . . . 300.2 fr. fr.

If this comparison is carried further to cover the capital invested, it appears that concrete sleepers are merely a means of supplementing or completing the supply of hardwood sleepers, a substitute which is either rather more expensive, or a little cheaper after 30 or 40 years.

However, the general use of double elastic type fastenings and the great extension of very long welded rails has put a completely different aspect on the question. The great savings due to both these modern techniques in association are so great (1) that they condemn the use of wooden sleepers with ordinary type fastenings (A and B) on the main lines for supporting short lengths of rails with fishplate joints. These joints alone account for about 30 % of the maintenance costs for the permanent way. As for hard wood sleepers with ordinary coachscrews, these involve heavy expenses for checking over and tightening up the fastenings.

For these reasons, a comparison of the working costs on important lines only leaves the field open to sleepers capable of carrying long welded rails, fitted with double elastic type fastenings. Even if supplies of hard wood sleepers remained normal, as well as the prices, and in every case where technical considerations (such as the layout of the line) do not dictate the solution, the choice between wood and concrete will be largely influenced by the observations made on the cost of maintenance.

Perhaps the solution will be to use different types of sleepers according to the expected life of the rails, the latter being a function of the amount of traffic, so that the sleepers will not have to be renewed in the period between two mechanised renewals of the complete track.

These considerations therefore justify the development of new technical formulae, such as concrete or prestressed concrete sleepers, concrete girders (longrines), etc., the economic advantages of which are not yet obvious at the present time but which may be found of great importance in a few years time.

(1) See *Revue Générale des Chemins de fer*, October 1953, p. 529 : Long welded rails. Extension of their use in France.

NEW BOOKS AND PUBLICATIONS.

[**385** (09 (45)]

Dr. Ing. G. DI RAIMONDO, General Manager of the Italian State Railways. — **Uno sguardo alle attività delle F.S. nell'anno 1954.** *(A review of the activities of the Italian State Railways in the year 1954.)* — Extract from the review *Ingegneria Ferroviaria*, No. 1, Jan. 1955. — One brochure (8 3/4 × 11 1/2 in.) of 38 pages, with 48 figures. — 1955, Roma, *Ingegneria Ferrovaria*, Piazza Croce Rossa.

Sorely stricken by the war, the Italian Railways rapidly rose from their ruins. The note from the General Manager describes the restoration work carried out during 1954, together with the modernisation programme, whilst the railway continued in operation.

In works and buildings, particular mention is made of the large bridges finally re-built with the idea of allowing them to take heavier trains. With the same object in view, the permanent way has been renewed in a stronger form. The report also mentions the various improvements made to the different lines and to a certain number of stations, and in particular accommodation for the staff.

The electrical installations include new substations for electric traction, central control of the signals, telecommunication lines, lighting and the transmission of current.

The chapter on the rolling stock indicates the chief innovations made in the case of the traction engines and passenger stock.

Better timetables have been introduced for both the passenger and freight services.

From the commercial point of view, the report analyses the evolution of the traffic, the steps taken as regards competition and the various improvements to the services.

Rationalisation measures have lightened the task and cost of the stores department.

In the accounts departments, various measures of simplification have been taken for the benefit of clients. The cost of the various kinds of transport have been calculated.

Two chapters describe the numerous activities of the staff and health departments.

The Research Institute has extended its activities to cover a great many very varied questions.

In the final chapter, the authors sums up in a few figures the constitution and production of the undertaking. He shows that the F. S. have been able to meet the increasing traffic requirements and that the programme now being carried out should result in the financial stability of the system and make it well adapted to the characteristics of the country and the requirements of the national economy.

E. M.

[625 .42 (45)]

Dr. Ing. Vito PERRONE, Inspecteur Général Supérieur de la Motorisation Civile et des Transports concédés. — **La Ferrovia Metropolitana a Roma.** *(The Rome Metropolitan Railway)*. — Reprinted from the review *Trasporti Pubblici*. Three volumes (7 7/8 × 11 1/2 inches) 150 pages in all, copiously illustrated. — 1952/1954, Roma, Istituto Poligrafico dello Stato.

The Metropolitan Railway of Rome owes its existence to the idea of linking up the centre of the city with the district in which the Universal Exhibition planned for 1942 was to be held. The new line was later called upon to serve and encourage the expansion of the Exhibition district lying to the south of the Eternel City. Everyone knows why the Exhibition was never held, but the idea of a Metropolitan Railway was taken up again after the war, as its usefulness appeared sufficiently justified not only by the service of the new district but also on account of the important internal traffic.

The three volumes devoted to a description of this remarkable work are a complete monography.

The First Part, covered by two volumes, relates to the line properly speaking. It contains notes on the legislation and acts of concession, a description of the layout (the line already built and future extensions), the cost of the work, the traffic expected, the operating programme and the expected economic results, the chief characteristics of the line, the stations, the chief difficulties encountered whilst the work was being carried out, as well as the very interesting archeological discoveries made while the work was being done.

There are a great many gradients on the line which starts from the Central Terminus Station of Rome and runs south alongside historical buildings to reach the plain where the exhibition was to have been held, across which it runs to a terminal freight station. It is 6 090 m (3.72 miles) long underground and 5 420 m (3.23 miles) in the open.

The numerous plans and drawings included in the text give very complete details about the work carried out on the line at the most dangerous places.

The Second Part relates to the equipment of the line and the rolling stock. Amongst the chapters mention must be made of : electrification, the rail motor coaches, the signalling, the telecontrolled substations, the telemeasures, the central equipment, the telephone, the lighting in the tunnels, the completion of the stations and the approaches thereto. Here again the author gives copious plans and drawings to show all the most characteristic arrangements of the fixed and moveable equipment.

This very brief summary can only give a very incomplete idea of Mr. Vito Perrone's beautiful book, which is worthy of the bold technical achievement it describes. Built under the City of the Seven Hills, winding and bending amongst historical monuments, the Rome Metropolitan must of necessity have certain absolutely original features. The engineer will be thrilled by the ingenuity and boldness of the arrangements adopted as well as by the ultra modern conception of the equipment.

E. M.

[**621** .13 (02 & **621** .137 (02]

LAMALLE (Ulysse), Directeur général honoraire de la S.N.C.B., professeur du cours de Chemins de fer à l'Université de Louvain, and LEGEIN (F.), Ingénieur en chef aux Chemins de fer de l'Etat belge. — **La Locomotora. Manual practico para los maquinistas y fogoneros.** *(The Locomotive. Practical handbook for drivers and firemen.)* — Translation by Antidio LAYRET, Industrial Engineer. — Second edition, revised and increased in conformity with the 4th Belgian edition. — One volume (5 3/4 × 9 in.) of 680 pages with 812 figures. — 1954, Barcelona. Editorial Gustavo GILI, S.A., Calle de Enrique Granados, 45.

The two authors of this work are well known to readers of this *Bulletin*. Their book : *The locomotive. Detailed Description of its components,* which goes back to 1913, was rapidly taken up by railwaymen. The fourth edition, on which this second Spanish translation is based, was reviewed in these pages in September 1948.

It is not necessary to go into the causes of the success of Messrs. LAMALLE & LEGEIN's work again. Addressed to the locomotive crews and maintenance men, it collects together in a most accessible form theoretical and practical information. No equipment, no component is left unmentioned, so that it is a complete guide and most invaluable aid.

It might be wondered whether, in view of the extended use of other methods of traction, these studies on the steam locomotive are still of value. But electric traction and Diesel traction, in spite of their qualities and the improvements made to them, have not completely vanquished steam. The latter still holds an important place in many countries, whilst awaiting new progress, and continue to render great service.

On the other hand, the steam locomotive has not gone unimproved. New devices have improved its output, increased its power, and strengthen its reliability.

It is to the credit of the authors to have profited by each new edition to make additions to their work, the interest of which has been shown by experience. The last bringing up to date has been done by Mr. LAMALLE since the unfortunate death of Mr. LEGEIN. The bases of the original work remain, but the additions have been so many that it is practically a new book.

The translator has done his work well and has given his readers a book worthy of the most recent conquests of the modern steam locomotive.

E. M.

[**385** (492)]

Dr. P. BOENDER. — **Die Niederländischen Eisenbahnen als kommerzielles Unternehmen.** *(The Netherlands Railways as a business undertaking.)* — Lecture given to the Institute of the Science of Transport at the University of Münster on the 1st October 1954. — One brochure (6 × 9 in.) of 28 pages. — 1955, Göttingen, Verlag. Vanderhoeck & Ruprecht. (Price : DM 2.50.)

Since the 1st January 1938, the Netherlands Railways have been amalgameted into a single undertaking. The Company is legally a private share holding company, although all the shares are held by the State.

The result of this statute has been to give the railway much greater freedom and enable it to be managed as a business undertaking. The State naturally retains its right of supervision as the public authority. The timetables and tariffs are

subject to approval. In addition, as shareholder, the Ministry of Communications has to intervene whenever for example there is question of participating in other undertakings or important extensions to the technical equipment.

In this way, the Netherlands Railways are in a somewhat different position to the other European railways which are nearly all directly operated by the State.

This study of Mr. Boender is intended to examine how the Management of the amalgamated railways has managed to profit by the methods left to its discretion and what results have been obtained.

The author explains the policy of the State as regards the different carriers. This may be put as five principles, amongst them the equal rights of all methods of transport and undertakings. It is on this basis and on the resulting commercial freedom that the activities of the railway can develop.

The various sectors are reviewed : the price policy, the organisation of both passenger and freight trains, the passenger stock, participation in other methods of transport.

Electrification and the use of railcars have resulted in improved comfort and increased speed.

The Company has been at pains to advise its clients of the services at their disposal. It has created an economic service responsible for relations with consignors and for investigations into any improvements considered necessary.

In spite of its condensed form, this work mentions many reforms introduced with the object of improving the financial position of the railway whilst serving the general economy of the country even better. We will only mention the organisation of the parcels traffic, the use of electric locomotives to haul goods trains by night and passenger trains by day, and spaced timetables for the passenger services.

The author reports an increase in the receipts due to the express passenger trains introduced in 1949, and a still greater increase in the short distance traffic.

Special mention is made of the intimate collaboration between the railway and an associated firm for the transport of parcels by road.

E. M.

[385 .6]

Dr. Werner HAUSTEIN, Head of the Legal Department of the Central Administration of the German Federal Railways. — **Die Freiheit im Internationalen Verkehr.** *(Liberty in International Traffic)*. — Volume 6 of the collection « Die Bundesbahn ». A cloth bound volume (5 1/2 × 8 1/4 in.) of 140 pages. — 1955, Darmstadt, Carl Röhrig, Verlag OHG, Stephanstrasse 8. (Price : Dm 12.—.)

Liberty in international traffic is a subject which has multiple aspects. Because it is less a question of complete liberty than of the shackles which impede it and the combined measures intended to avoid the too numerous restrictions which still restrict exchanges of traffic. When it is considered that transport has to respect the internal legislation of the country through which it runs it is obvious that the problems to be solved are often very complex, quite apart from the customs barriers.

On the other hand, various methods of sending forward are used for exchanges of traffic. In addition to the transport of persons and goods carried by the railway, the road, internal waterways, maritime navigation and airlines, there is also the transmission of ideas and news by means of the post, telegraph and wireless wave lengths.

The author has dealt with all these possibilities of communication and, naturally he has not neglected the question of com-

petition which exists more or less freely between the different methods of transport.

Dealing with the matter from the point of view of all possibilities of exchanges and transport on the international plane, the author reports the genesis of the treaties and conventions passed between States and analyses them, often quoting lengthy extracts. He also mentions the great International Transport Unions and defines their work of facilitating relations between different peoples.

At the end of the work there is a list of the multilateral agreements passed in the field of international traffic law. In each case the place and date is given, the date upon which it came into force and the publication where the official text can be found.

E. M.

[**385** (09 (3)]

World Railways 1954-55. A world-wide survey of Railway Operation and Equipment. Third edition. Composed and published by H. SAMPSON. — One volume (8 3/4 × 13 in.) of 462 pages, with numerous illustrations and maps. — 1955, London, W1 : Sampson Low's « World Railways » Ltd, 25, Gilbert Street. (Price : £ 4.4.0 net).

This third edition has appeared two years after the last one which shows the interest taken in the work by engineers and many industrialists engaged in making railway material.

The book has been brought up to date to take account of progress made in the meantime.

Information about old traction and transport material has been left out in order to leave room for new chapters, such as those dealing with Metropolitan Railways, the builders of rolling stock, Diesel locomotives, and a series of articles describing ultra-modern applications.

The section dealing with Metropolitan Railways gives full details about existing lines, with maps, and about proposed lines. The manufactures of a great many firms are described in detail. A very great diversity of traction locomotives use Diesel engines. The four articles which end the book deal with air conditioning in passenger coaches, electrification using industrial 50 cycle frequency, Talgo trains and disc brakes.

Throughout the book will be found proofs of the efforts made by railway operators to make their railways more efficient and more economic. In this order of ideas mention may be made of : the constitution of the track and maintenance methods, signalling and telecommunications, the equipment and organisation of marshalling yards, the standardisation of wagons, quick release wagons, sending road vehicles by rail.

Whatever the importance of these questions, however, they are all dominated by the question of the traction engines. On the two chief competitors of steam : electric traction and Diesel traction, the reader will find much information tied up with the realisation already made and the designs under trial, together with detailed descriptions of the stock in service.

Mention must also be made of the gas turbine locomotives, a large number of which are in service on the Union Pacific Railroad (described in the 1952-53 edition) and others in England and France.

All railways of any size are mentioned in World Railways together with the constitution of the undertaking, the layout and profile of the lines, the construction of the track, the traffic, the method of operating, the mileage and the composition of the rolling stock.

These few lines only give a feeble idea of

the very considerable amount of information collected together in this volume. It is very copiously illustrated, particularly with maps of the railways, gauges and loading gauges, and the most noteworthy examples of traction and rolling stock.

« World Railways » is a precious work of reference for all those interested in the railway : the engineer, the operator, the builder and the supplier of various materials.

E. M.

[621 .436]

Diesel engines. — Their industrial application. — Special edition (December 1954) of *Technique Moderne*. One volume (9 1/2 × 12 in.) of 112 pages, illustrated. — 1954, Paris, Dunod, Publisher, 92, rue Bonaparte. (Price : 850 Fr.fr.)

The Diesel engine is now so widely used that a study of its evolution and its possibilities could not fail to be of the greatest interest. *Technique Moderne* has given its readers in this special number a series of articles from the pens of authors qualified by the position they hold in industry or teaching.

Preoccupied above all with the choice and utilisation of the engines, the authors have not wished to go into the fundamentals of the problems concerning the physiology of this way of producing power. But they have brought out the improvements which have made the internal combustion engine a well designed and well tried engine. They have also pointed out the reasons for its widespread use : the fact that it is self-contained, its massive power and its high output.

Amongst the numerous applications considered are railway traction, standby generator sets, electric power stations, motor compressors and marine engines.

From the point of view of its construction, mention may be made of an article on the evolution of the injector and another on superheating. Under the same heading may be included the articles describing the very powerful engines and those of average power which are air cooled.

The question of the oils to use and lubricants are the subject of three articles which will be much appreciated by operators. These will also derive much profit from a report on the very important question of the maintenance of Diesel engines.

We may also mention a study on the elastic link between the Diesel engine and driving engine considered in terms of industrial applications, on marine engines and locomotives.

This work can be recommended to builders, industrial firms using Diesels, and the staff responsible for driving and maintaining them.

E. M.

[313 : 656]

Bulletin Annuel de Statistiques de Transports, 1953. *(Annual Bulletin of Transport Statistics*, 1953.) — Published by the Economic Commission for Europe. Transport Division, United Nations, Geneva. — One volume (8 1/4 × 11 in.) of 132 pages with diagrams and maps.

This is the fifth Bulletin in this series, the year 1949 being the first covered by the investigations of the Commission.

It contains statistics relating to three methods of transport : rail, road, inland waterways and maritime ports.

The data collected are compared with similar data for 1949 and, often when the

variations are considerable, with those of the intermediate years.

The work is divided into four chapters : the traffic, the systems, the rolling stock, the use of the stock.

The statistical tables are of two kinds : the principal tables grouped together at the end of the book and tables inserted in the text, more restricted in matter, to stress certain factors considered to be of particular interest.

The text gives a commentary calling attention to the comparative results of the years under consideration, with a study of the circumstances which affected transport, and appreciations of the steps taken and the projects under consideration.

In general the statistics show in figures facts of real interest from the point of view of the evolution of transport and economy.

During the period studied, economic activity was intense and production increased.

We can read in the first chapter the remarks of the Commission on the march of traffic (passengers and freight) and on the development of road transport.

The second chapter throws into relief the progress of electrification of the railways, the falling off in steam traction and the more or less complete cessation of the building of new lines.

In the third is given the influence of the new techniques on the composition of railway rolling stock.

In the fourth, which deals more particularly with the railway, will be found the tangible results of the efforts made to obtain a better user of both the lines and the stock and a general increase in productivity.

E. M.

[**62** (03 : **656** .25]

Dr. Ing. habil. W. SCHMITZ. — **Englishes Wörterbuch für Eisenbahnsignalwesen und Fernmeldetechnik. English-Deutsch. Deutsch-English.** *(Dictionary for Signalling and the Technique of Telecommunications. English-German. German-English)*. — Two volumes (4 1/2 × 6 1/2 in.) of 246 and 202 pages respectively. — 1954, Franckfurt a. M., Dr. Arthur Tetzlaff, Verlag, Niddastrasse, 64.

Working the track equipment and signals by means of fluids has long been current practice on the railway. After trials and applications using fluids of various kinds, sometimes in combination, the simple solution of control by electricity alone was arrived at. We are now in the period of improvements and extensions to this practice.

Thanks to the immense possibilities of electricity, the search for economy and the desire to shorten the time of working has led to astonishing progress being made in this field.

The result is a very varied special technique.

The work to be done has led to the creation of new equipment for which new names had also to be found. Even different combinations of equipment gave rise to a need for terms which did not exist in current technical language.

It will therefore be readily understood that the ordinary technical dictionaries, in spite of their great usefulness, are of too general a character to be of great assistance in the case of signalling.

The object of the author has been to provide for students at the German Technical Institutes and Signalling engineers a work which would make it easier for them to read the copious English and American literature on this subject.

Owing to the close relationship between

signalling and telecommunications and the important part played by the latter in the working of a railway, the author has included in his work all the terms relating thereto.

To keep the size of the dictionary within reasonable limits, words whose meaning is impossible of misinterpretation have been left out.

Reading these two volumes, we are constantly struck by the fact that terms composed of words in current use often have a special and well determined meaning when applied to signalling. The usefulness of such a dictionary lies in the fact that it makes available a literature which otherwise would be a closed book to any readers who lacked the necessary information.

Signalling being in a state of constant evolution, this second edition has been improved by the addition of further words the need for which has been shown by recent applications.

E. M.

MONTHLY BIBLIOGRAPHY OF RAILWAYS[1]

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

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016. 385. (02]

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In French.

955 624 .9

ES (L.).

Calcul des ossatures des constructions. Détermination la sollicitation des éléments constituant les ossatures. Bruxelles, Centre Belgo-Luxembourgeois d'Informa- n de l'Acier, 3, rue de la Science. Un volume (20 27 cm) de 384 pages, avec de nombreuses figures.

955 744

)UET (R.) & DUBUISSON (B.).

Cours de dessin topographique.

Paris, Eyrolles, éditeur, 61, boulevard Saint-Germain. volume (16 × 25 cm) de 180 pages, 116 figures, 1 rs-texte en dépliant. (Prix : broché, 980 fr. fr.)

1955 621 .3

GILLON (G.).

Cours d'électrotechnique. III[e] Partie : *Centrales élec- ques, réseaux, applications diverses.*

Paris, Dunod, éditeur. VIII-568 pages (16 × 25 cm) ec 528 figures. (Prix : broché, 3 600 fr. fr.)

1955 621 .436

ELDT (P. M.).

Les moteurs Diesel à grande vitesse pour l'automobile, éronautique, la marine, la traction sur rail et les plications industrielles. 5[e] édition.

Paris. Dunod, éditeur, 92, rue Bonaparte. Un volume ié (16 × 25 cm) de XVI-464 pages, avec 291 figures. ix : 2 900 fr. fr.)

1955 625 .28 (493)

Journées Internationales de la Traction dans les Chemins fer, Liège (avril 1955). Numéro spécial (Juillet, 1955) la *Revue Universelle des Mines.*

Liège, *Revue Universelle des Mines*, 22, rue Forgeur. n volume (210 × 297) de 150 pages contenant les rapports présentés par des spécialistes belges et angers et ornés de nombreuses illustrations. (Prix : 5 fr. belges.)

1955 385 (08 (675)

OFFICE D'EXPLOITATION DES TRANSPORTS COLONIAUX (OTRACO).

Rapport 1954.

Bruxelles, OTRACO, 101, avenue Louise. Une brochure (22 × 29 cm) de 58 pages, avec tableaux, graphiques et photos hors texte.

1955 621 .43

SEILIGER.

Moteurs et turbines à combustion interne.

Paris, Dunod, éditeur, 92, rue Bonaparte. Un volume (16 × 25 cm) de X-298 pages, avec 160 figures. (Prix : relié toile, 2 950 fr. fr.)

In German.

1955 691

Prof. W. GEHLER & Ch. PALEN.

Erläuterungen zu den Stahlbetonbestimmungen. 6. Ausgabe.

Berlin-Wilmersdorf, Wilhelm Ernst & Sohn, Hohenzollerndam, 169. Ein Band (15 × 21 cm) von 312 Seiten, mit 111 Abbildungen. (Preis : geheftet, DM 18.—; gebunden, DM 21.—)

1954 531

Prof. Dr.-Ing. Heinrich HEYDE.

Mechanik für Ingenieure. Band I : *Statik und Dynamik.* 3. Auflage.

Leipzig, B.G. Teubner Verlagsgesellschaft. 333 Seiten mit 316 Bildern. (Preis : geb. DM. 11.80.)

1955 691

LEONHARDT (F.).

Spannbeton für die Praxis.

Berlin, Wilhelm Ernst & Sohn. Ein Band (17 × 27 cm) von 500 Seiten mit 658 Abbildungen und 21 Tafeln. (Preis : DM 59.—.)

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Dr.-Ing. W. LINDNER.

Zahnräder. Früher bearbeitet von Prof. Dr. A. SCHIEBEL. *Band I* : Stirn- und Kegelräder mit geraden Zähnen. 4. Auflage.

Berlin, Springer-Verlag. 133 Seiten (19 × 27 cm) mit 183 Abbildungen. (Preis : DM 18.—.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress jointly with the Office Bibliographique International, of Brussels, (See « Bibliographical Decimal Classification as applied to Railway ence », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, p. 1509.)

In English.

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ALLEN (CECIL J.).
The Great Eastern Railway.
One volume (5 1/2 × 7 in.) of 222 pages, illustrated.
Hampton Court, Surrey : Ian Allan Limited, Craven House. (Price : 25 s.)

1955 **385** (061 .4 (73)
Association of American Railroads. Signal Section. Advance Notice. Reports to be presented at the Fifty-Sixth Annual Meeting, New Orleans, LA. October 11, 12 and 13, 1953.
One brochure of 193 pages.
Publishers : A.A.R., 59, East Van Buren Street, Chicago 5, Ill.

1955 **691**
BILLIG (KURT).
Precast concrete.
London : Macmillan and Co. Ltd., St. Martin's Street, W. C. 2. (Price : 32 s.)

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FERGUSON (T.).
Electric railway engineering.
One volume (5.9 × 9.1 inches) of 416 pages, illustrated.
London : Macdonald Evans Ltd., 8, John Street, Bedford Row, W. C. 1. (Price : 57 s. 6 d.)

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HAMMOND (ROLT).
Foundation engineering.
One volume (8 3/4 × 6 inches) of 192 pages, illustrated.
London : Oldhams Press, Ltd., Long Acre, W. C. 2. (Price : 21 s.)

1955 **625 & 656** .2
HAY (W. W.).
Railroad engineering. *Vol. I.* One volume (6 × 9 1/4 inches) of 483 pages, illustrated.
London : Chapman and Hall, Ltd, 37, Essex-Street, W. C. 2.

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I.T.F.-Reports 1952-1953 and Proceedings of London Congress 16-23 July 1954.
One volume (6 1/4 × 9 1/2 inches) of 351 pages
London : International Transport Worker's Federation, Maritime House, Old Town, Clapham, S. W. 4

1955 **62**
KEITH SWAINGER.
Analysis of deformation. *Volume I* : **Mathematical theory;** *Volume II* : **Experiment and applied theory.**
London : Chapman and Hall, Ltd., 37, Essex-street W.C.2. (Vol. 1 : 63s.; Vol. II : 70 s.)

1955 **621** .3
KOEHLER GLENN.
Circuits and networks.
One volume (9 1/2 × 6 1/4 inches) of 349 pages, bound
New York N.Y. : Macmillan Company, 60, Fifth Avenue. (Price $ 6.50.)

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LESSELLS (J. M.).
Strength and resistance of metals.
London : Chapman and Hall Ltd. 37, Essex-Street W.C.2. (Price : 80 s.)

In Italian.

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1955 **625** .13 (931)
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